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Director's Discretionary Fund Report for FY 1991

July 1992

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July 1992

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035-1000

INTRODUCTION

The Director's Discretionary Fund (DDF) at Ames Research Center was established to fund innovative, high-risk projects in basic research which would otherwise be difficult to initiate, but which are essential to our future programs. A report is issued annually presenting summaries of individual projects within this program.

These summaries are for both final and ongoing projects in Fiscal Year 1991. The narratives are presented first, followed by an appendix. The appendix contains a brief description and the financial distribution and status of each of the 40 projects. Five projects began at the end of the fiscal year so no narrative reports were submitted, but their status reports appear in the appendix.

The contents are listed alphabetically by the last name of the first investigator.

Any questions can be addressed to an investigator directly.

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Characterization of Vortex Impingement Footprint Using Non-intrusive Measurement Techniques

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Objectives of the study
1. Characterize and verify the on-surface vortex footprint using high frequency, nonintrusive measurement techniques. Define the vortex core, direction of rotation, surface path, and vortex burst location.
2. Develop and refine data analysis techniques currently used in wind tunnels. Develop software to automatically interpret data and provide quantitative information on the vortical flow.
3. Disseminate measurement techniques and resulting data base to aero-technical community for further research and development.

Progress and results
Water tunnel flow visualization tests have been performed to document vortex patterns and to select optimum vortex generator configuration for study. Flat plate generators were selected as optimum and an airfoil model is being set up for test with hot films in a flow calibration facility. The flow calibration facility is being set up for tests. Several noise sources were found and are being eliminated for calibration tests. Software development for analysis of data is currently ongoing using hot-film data obtained from the F-16XL Supersonic Laminar Flow program.

Significance of the results
Results to date are of no significance other than to assist in identifying hot-film sensor layout and appropriate spacing for flow calibration tests and future flight tests.

No reports of publications have resulted from the study to date.

Feasibility Study for an X-ray Diffractometry Instrument with X-ray Fluorescence and X-ray Photoelectron Spectroscopy Capabilities for Remote Planetary Missions

Investigator(s)
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Other personnel involved
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Objectives of the study
The overall objectives of this study are to design, fabricate, and test a breadboard prototype of a combined X-ray diffraction and X-ray fluorescence instrument suitable for planetary missions. The information that this instrument collects from a sample (spacings between atomic planes in crystal structures and major element composition) should allow the mineralogic identification of surface soils and other unconsolidated fine-grained samples.

Progress and results
In the first year of the study, we have made progress in both the conceptual design of the instrument and in the fabrication of a suitable test bed for establishing its performance characteristics. Charles Bryson and Friedemann Freund and I have identified a suitable geometry for the instrument, as well as an X-ray generation and collection strategy.

The geometry of the instrument will be that of a microfocus X-ray camera, with an energy-dispersive X-ray charge-coupled device in place of the film cassette. The camera arrangement minimizes the absolute size of the instrument as well as providing for a collection geometry in which high-angle diffracted beams can be recorded. A large solid angle of collection exists for X-ray fluorescence detection. The X-ray source will be a low-power X-ray tube, with a parafocusing crystal used both to monochromate the source and to provide the appropriate intensity of Cu X-rays at the sample.

We have installed a Philips X-ray generator (moved from another building and put back in commission) in my laboratory and have just completed a full check-out of the electronics and safety devices by an outside contractor. The X-ray generator is now fully operational and only requires certification by Ames Research Center safety personnel. We have two of the old-style microfocus X-ray cameras, one to be used with a film cassette to study the geometry of the instrument, and the second to be modified to accept a CCD in the second year of funding.

Significance of the results: None so far

Publications resulting from study: None so far

References: None so far

Radical Measurement by Zeman Spectroscopy (RAMZES): A Prototype Instrument for Airborne In Situ Measurements of Radical Molecular Species

Investigator(s)
T. A. Blake,[1] C. Chackerian, Jr., and J. R. Podolske
Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study
The purpose of this work is to develop a laboratory prototype for an ultra-sensitive detector that can be used for the quantitative measurement of free radical molecular species which are found in very low concentrations in the Earth's stratosphere. The detection scheme will exploit the selectivity which magnetic rotation spectroscopy has for free radical molecular species which are paramagnetic. The laboratory prototype will be used to determine sensitivity limits affected by various of the apparatus' parameters such as magnetic field homogeneity, polarizer efficiency, quality of optical surfaces, and modulating schemes, such that limiting factors on the instrumental sensitivity can be understood. Then it will be desirable to incorporate a Herriott multiple reflection cell to further increase the sensitivity and to use two infrared lasers simultaneously: one for the detection of nitrogen oxide and the other for the detection of nitrogen dioxide. Further, we believe that the sensitivity of the instrument can be increased by simultaneously employing both right and left circular polarization components. A similiar experiment, under the aegis of the Ames/Stanford Institute for Global Change, is under way to develop a magnetic rotation detector for the hydroxide molecule. These experiments will be done in the ultraviolet spectral region (309nm) with a ring dye laser.

Progress and results
To date a number of items of equipment have been ordered. These include a tunable diode laser to operate at 1875 cm^{-1}, a monochromator, a Brewster angle polarizer, a quarter-wave plate, a HgCdTe IR detector, a locking amplifier and a magnet power supply. In addition a small solenoid was made, and its magnetic field distribution was measured to test our understanding of the magnetic units and the equations which describe the field. Trim coils were added to "flat field" the solenoid. A resonant (tank) circuit was designed to use with the solenoid and the AC magnet power supply. A large diameter solenoid from Johns Hopkins University was refurbished for use with the OH experiment. Polarizers (309 nanometer) were ordered for this experiment.

[1]NRC Postdoctoral fellow.

Polarization Measurement of the Infrared Emission Bands from PAH Molecules

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Michael Werner, Jet Propulsion Laboratory,
Pasadena, CA

Other personnel involved
David Rank, University of California ,
Santa Cruz, CA
Laura Kay, Barnard College

Objectives of the study

In the 3-4μm spectral region, there are a series of sharp emission bands at 3.29, ≈3.40, and ≈3.57μm, and an underlying broad band stretching from about 3-3.8μm. The 3.29μm band is almost certainly from the C-H stretch in polycyclic aromatic hydrocarbons (PAH), but the origin of the other bands has been debated in the literature. The two most likely scenarios are either that the 3.40 and 3.57μm bands arise from excited states in the PAH molecules, or that these bands are not produced by PAH's but are due to side chains of non-aromatic organic radicals in linear molecules. The broad underlying band is presumed to be due to the overlap of many weak sharp bands, but little evidence exists to support this view.

We proposed a new technique for studying the origins of the PAH emission bands by using polarized light. PAH molecules are flat, and so the C-H stretching modes, which give rise to at least the 3.29μm band, occur in a well-defined plane. Thus, by comparing the polarization of the 3.29μm band with that of the 3.40 and 3.57μm bands, we expected to be able to determine whether the other bands also were due to the same C-H stretch or to side groups in other molecular species; in the latter case, they would not show the same polarization. Observing a net polarization due to this effect requires that the PAH molecules be aligned, not randomly oriented. Other observations have shown that interstellar grains are aligned by magnetic processes; these are known to align graphite grains in the interstellar medium and may also orient the PAH molecules, which can be thought of as very small graphite flakes. In addition, the platelike PAH molecules may be subject to alignment by streaming or dynamical effects.

Progress and results

Originally we planned to build a polarimeter to go in front of an existing spectrometer. As we progressed with the design, we realized that a much more sensitive approach would involve using a two-dimensional infrared array in a spectrograph and measuring the two orthogonal polarizations simultaneously. We therefore have put most of our effort over the past 2 years into developing 2-D infrared arrays. In collaboration with David Rank at Lick Observatory, we have succeeded in constructing two different 128×128 infrared array cameras, one for the 1-5μm spectral region and the second for the 5-18μm spectral region. These cameras have the largest spatial coverage of any infrared cameras now operating beyond 2.5μm, and they will produce exciting and significant results.

These cameras have performed very well and have resulted in some data that has been published. A picture of the center of our galaxy at 2.2μm appeared on the cover of Laser Focus World (July 1991) along with a short description of the photograph inside the magazine. In addition, data from the InSb camera was included in a paper we just submitted to the Astrophysical Journal titled "Extended PAH Emission Around IRAS 21282 + 5050." The manuscript would not have been submitted without this data. We have also constructed a polarimeter and obtained some test polarization data a few weeks ago. The cameras and polarimeter will be operated at the Mt. Lemmon observatory in Arizona starting on November 1, 1991, and we expect to obtain polarized images through a filter that isolates the strong PAH emission band at 3.3μm. Thus, the project is continuing and we will soon have an initial indication of whether PAHs are indeed polarized.

Significance of the results

We have found that the large organic molecules that are found around certain astronomical sources are formed more profusely than previously thought.

Feasibility of Light Emitting Diode Arrays as a Lighting Source for Plant Growth Chambers in Space

Investigator(s)
David Bubenheim, Raman Sargis, David Wilson,
Mark Turner, and Peter Haddeland,
Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study

To determine if light emitting diodes (LED) offer the potential solution to problems of power consumption, light intensity, volume, and maintainability, which plague the design of all lighting systems for space-based plant growth chambers.

Progress and results

Efficiency of electric power conversion to photosynthetically active radiation (PAR) and delivery

	Red LED	Metal halide	Fluorescent
Electrical conversion to PAR	11%	32%	12%
PAR delivery efficiency	95%	80%	50%
Total efficiency	10%	26%	6%

Results of crop growth tests

1. At equal photosynthetic photon flux levels, growth of wheat plants was suppressed when grown under the reduced spectrum provided by the red or red + far-red LED arrays as compared to white light.
2. The addition of far-red radiation to the red LED environment did not affect biomass accumulation; however, development was accelerated by approximately 7 days compared to the red and white light environments. At harvest, 30 days after germination, heads were emerging (indicating the end of the stem elongation phase) in plants growing under the red + far-red LED array; plants under the red and white light treatments had just entered the stem elongation phase.
3. Preliminary results of crop testing indicate that while the photosynthetic capacity of plants grown under the LED arrays is not equivalent to that of plants grown under white light, the processes proceed at a sufficient rate to allow growth and apparently normal development.
4. LED arrays appear to be feasible for use in plant growth chambers for physiological research in space. Results thus far indicate that LED arrays would not be an acceptable alternative for crop production devices, but would be appropriate for study of development processes in the microgravity environment.
5. The LED array characteristics of long operational life, increased safety, consistent performance, and reduced system volume, compared to traditional plant lighting sources for space applications, had offset the observed suppression in photosynthetic capacity of plants in many situations.

Significance of results

The engineering advantages of LED arrays are:

- LEDs have a long life span (10 to 20 years)
- LEDs have improved delivery efficiency of photosynthetic photons once converted from electricity, compared with traditional lamps
- LEDs can operate on small amounts of power but could utilize higher power input to supply greater photosynthetic photon flux
- LEDs do not contain harmful gases, as conventional sources do

- LEDs can be packaged in an array taking up little volume

Future work

Future work will emphasize two topics for completion of the DDF project:

1. Complete the efficiency analysis defining conversion efficiency of input power to photosynthetic radiation and the delivery of that photosynthetic radiation to plants for LED arrays and traditional plant lighting sources.
2. Conduct crop growth tests with models of different crop types. Conduct seed-to-seed experiments with wheat to determine that all phases of development occur normally, and conduct similar growth evaluation tests with soybeans and lettuce. Wheat is a model monocot grain, soybean a dicot grain, and lettuce a model salad crop.

Origin of Life: Exploration of Water/Air Interface as a Reaction Zone for Condensations

Investigator(s)
Sherwood Chang, Ames Research Center, Moffett Field, CA 94035-1000
Anastassia Kanavarioti, University of California, Santa Cruz, CA

Other personnel involved
Michael Stronach (postdoctoral fellow) joins on Oct 9, 1991.

Objectives of the study
To examine whether water/air interfaces on the early Earth (such as occur in bubble formation at the sea surface, in thermal springs and subaqueous natural gas vents, in cloud droplets, aerosols) may have influenced the synthesis of biologically important molecules.

Progress and results
We focused our attention on developing an apparatus that will allow us to quantitatively test the effect of water/air interface on a specific reaction, i.e., on the reaction rate and the product distribution. To that effect, we bubble nitrogen through small glass frits that are inserted in 4 ml of reaction mixture placed inside long glass test tubes. The test tubes are covered with parafilm and are placed inside a thermostated water bath. The first experiments were performed at room temperature. We noticed that some evaporation occurs, mainly because of the bubbling, and therefore we included in the protocol the addition of a compound that serves as an indicator. All test tubes contain the same amount of the indicator so that all the measurements can be calibrated based on the amount of this internal standard. In order to test this setup, we performed a set of reactions with nucleotides that we have investigated in the past, and for which we know rates and products, as well as the method of analysis. Some of the test tubes included a surfactant (tetramethyl ammonium phosphate) that dramatically enhances the amount of water/air interfaces. For the reaction tested, a hydrolysis reaction, neither the bubbling nor the surfactant had any significant effect. So far, we proved to ourselves that it is possible to get reliable quantitative results with the above protocol.

Future plans
We intend to test reactions such as (i) condensation of amino acids to peptides, (ii) condensation of glycerol, phosphate and fatty acids to form phospholipids, and (iii) fixation or reduction of carbonate to form formaldehyde and/or formic acid using the above protocol or modifications thereof as needed.

Human Exploration Demonstration Project

Investigator(s)
Edward Chevers and David Korsmeyer,
Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study

The Human Exploration Demonstration Project (HEDP) is a multi-Division task that addresses the advanced technology requirements necessary to implement an integrated working and living environment for a planetary surface habitat. The HEDP project began in the fall of 1991. The integrated environment will consist of life support systems, physiological and psychological monitoring of the flight crew, a virtual environment workstation, and centralized data acquisition and habitat systems health monitoring. Artificial intelligence programming techniques will be used extensively to provide an automated environment for the crew. There will be several robotic systems external to the habitat that perform activities to provide representative workloads for the human subjects.

Figure 1. The robotic rover system and the lunar terrain simulator.

Four basic goals for the Human Exploration Demonstration Project have been established:

1. Provide a simulator for evaluation of technology in an integrated system setting.
2. Create a realistic environment for introduction of new technology.
3. Enhance the technology development and evaluation process through synergistic cooperation of multiple Ames divisions.
4. Identify promising technology concepts to programmatic Centers for new and existing NASA projects.

Progress and results

Progress to date for the HEDP has focused upon two areas: the development of a lunar exploration environment and the rehabilitation of the altitude chamber in building N-239A. The lunar exploration environment consists of the two T-1 robotic rover systems, and the preliminary lunar terrain simulator (see the figure).

The rehabilitation of the altitude chamber started in the last quarter of 1991. Now known as the Controlled Environment Research Chamber (CERC), it consists of a main chamber vessel and an attached airlock. The main chamber is a 16-ft diameter vertical cylindrical vessel, the lower half of which extends into a pit below the floor of Building N-239A. Two decks, each having a working area of 165 sq ft, are contained within the main chamber. It is envisioned that these two decks would provide the necessary space for the HEDP living environment. The uppermost of the two decks is entered through the 8-ft diameter horizontal cylindrical airlock. Access to the lower deck is achieved from the upper deck using an internal, wall-mounted ladder.

Significance of the results

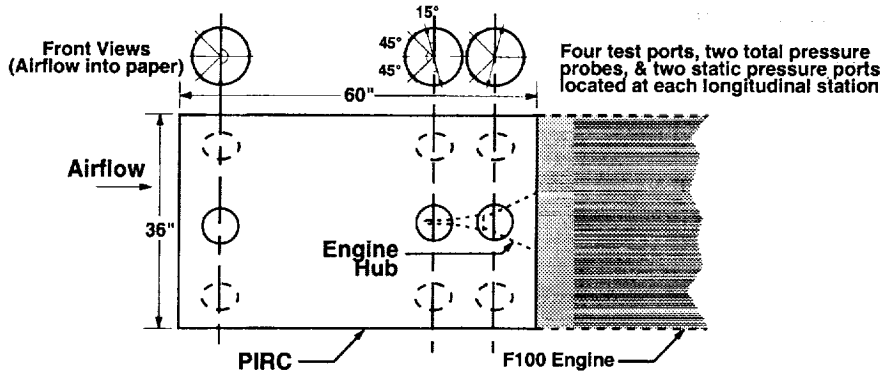
The robotic rover system and the lunar terrain simulator were demonstrated at the Automation Sciences Research Facility dedication ceremonies. They showed the capabilities and strengths of an autonomous vehicle performing a wandering exploration task in a rocky environment.

Propulsion Instrumentation Research Chamber

Investigator(s)
Timothy R. Conners, L. Dean Webb,
Sheryll A. Powers, and Ronald J. Ray,
Ames Dryden Flight Research Facility,
Edwards, CA 93523-0273

Objectives of the study
The major objective of our DDF task was to develop a low cost facility for testing instrumentation designed for use in propulsion systems. Many types of instrumentation designs in development promise a revolution in engine diagnostics and control, particularly nonintrusive sensors. The Propulsion Instrumentation Research Chamber (PIRC) was created to accelerate the transition of these new systems from development to the flight environment. The PIRC, designed to fit between a bell-mouth and F100 turbofan engine on a ground test stand, provides a low-cost facility for inlet and engine face testing. It will accommodate different types of instrumentation while subjecting the sensors to the real-world environment of an operating engine. Hands-on experience with new instrumentation can be gained at a low cost per test.

Progress and results
Requirements and preliminary design for the PIRC, shown below in a side view, were finalized in January of 1991. The system design was balanced to provide a suitable test facility for various types of instrumentation while keeping construction costs low. Final design of the chamber was sub-tasked to PRC, Inc. It is presently being manufactured by King Welding (Camarillo, Ca) and is scheduled to be delivered to Dryden by the end of October 1991. We are currently formulating a plan for testing the PIRC at the Pratt & Whitney engine test stand at Edwards AFB. Dryden has at its disposal a non-flightworthy F100 turbofan that would be available as the ground test engine. Flight projects (F-18 HARV in particular) and Pratt & Whitney have shown interest in using the facility to test diagnostic instrumentation. We are also pursuing a Phase II SBIR program for developing laser instrumentation for engine flow studies. The PIRC would provide an ideal test facility if this program is awarded.



Scheduling Electrical Power for Ames Research Center

Investigator(s)
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Other personnel involved
Kimball Collins, Sterling Software,
Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study

The objective of this study is to investigate the application of constraint-based scheduling and iterative improvement optimization techniques to the wind tunnel operations domain. Aerodynamic testing at Ames costs on the order of $1 million per month in electrical power. Reduction of power and other costs is achieved by scheduling tests in such a way as to optimize soft constraints, such as schedule length and power cost, while satisfying hard constraints such as wind tunnel availability. This is a constrained optimization problem for which there is no known practical algorithm for finding an exact solution. Approaches to finding good solutions are a current area of research in artificial intelligence. This project applies this recent research to wind tunnel scheduling and contributes knowledge gained in this unique domain.

Progress and results

This work is still in progress and continues under Code RAF funding. Several techniques were developed to formulate the problem in terms of constraint-based scheduling. Software developed for space shuttle ground operations scheduling was changed to model most of the many domain parameters that are necessary for effective optimization, and an architecture was developed for the final system. The initial knowledge acquisition and modeling phase is nearly complete. Domain knowledge is at a level of detail greater than is presently used for power cost reduction. Data from actual tests is being converted for evaluation.

Significance of the results

The wind tunnel domain is both more interesting and more complex than originally estimated. It requires modeling at a high level of detail, with a large number of tasks and many on-the-fly calculations that affect model state. The natural structure of the problem appears excellent for certain refinements to the constraint satisfaction and iterative improvement paradigms; hierarchical abstraction in particular, and learning and probabilistic inference in general, might prove to be of value in this domain.

Publications resulting from study

A brief overview of this work was presented at the Information Sciences Applications to Aeronautics Workshop at Ames in July, 1991. A more detailed paper is being prepared.

A Resonant Ge:Ga Far Infrared Photoconductor

Investigator(s)
Jam Farhoomand, Orion TechnoScience, Palo Alto, California
Robert E. McMurray, Jr., Ames Research Center, Moffett Field, California 94035-1000

Other personnel involved
Kohei Itoh, Bill Knowlton, and Eugene Haller, Lawrence Berkeley Laboratory

Objectives of the study

Quantum efficiency is perhaps the single most important parameter of an infrared photoconductor. Attempts to improve this parameter have lead the investigators to devise methods of increasing the absorption properties of detectors. We propose a novel approach to achieve unit quantum efficiency and enhance the photoconductive gain while at the same time keeping the physical length of the detector element small and the dopant concentration low. This objective is accomplished by creating a resonant absorption cavity internal to the detector element. The figure shows a typical cross sectional diagram of a resonant infrared detector. To demonstrate this concept, a standard Ge:Ga detector will be thinned down to about 50 μm with the front and back surfaces parallel to within 0.5 μm across a 2×2 mm^2 area. The back surface of the detector will be gold coated for 100% reflection. The front surface will also be gold coated to achieve proper reflectivity.

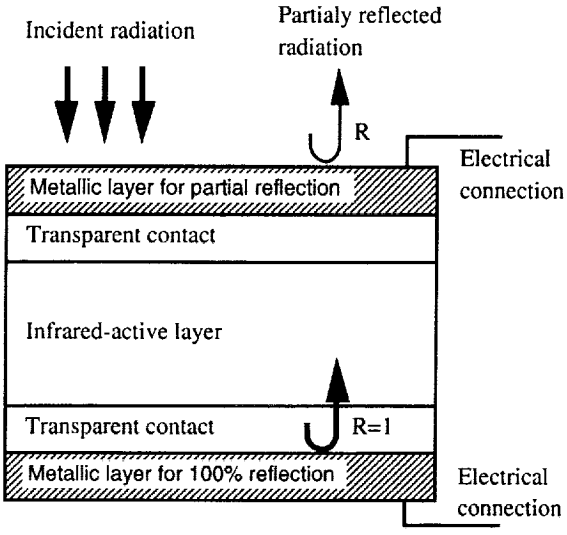

Figure 1. A typical cross sectional diagram of a resonant infrared detector.

Progress and results

As part of this project, a theoretical study has been carried out to determine under what conditions improved quantum efficiency can be achieved. The results of this study were better than expected and have been published. The first step in fabrication of the detector is to develop a precision lapping and polishing technique to thin down the detector. Several germanium wafers have been used as test pieces to perfect this process. The progress so far has been excellent. With the present technique, one can produce wafers that meet the required specifications. It is yet to be determined, however, whether this lapping and polishing technique would damage the detector on a microscopic level. Design and development of a test setup have been concurrently under way. The necessary optics, electronics, and ancillary equipment have been fabricated and assembled. One important and pivotal feature of the fabrication of this detector is the deposition of the right thickness of gold on the front surface to achieve the required reflectance. In doing so, extensive testing has been carried out to determine the reflectivity of gold as a function of its thickness. Further tests are needed to develop a more reliable model.

Publications resulting from study

Farhoomand, J.; and McMurray, R. E.: "A Resonant Infrared Photoconductor with Unit Quantum Efficiency," Proc. 16th Int. Conf. on IR & MM Waves (1991).

Farhoomand, J.; and McMurray, R. E.: "Design Parameters of a Resonant Infrared Photoconductor with Unity Quantum Efficiency," Appl. Phys. Lett. **58**, 622 (1991).

Fully Coupled Structural Deformations and Computational Fluid Dynamics: Direct Solutions Using Newton's Method

Investigator(s)
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Objectives of the study

The principal objective of this research is to develop a procedure for the direct solution of static aeroelasticity problems. A direct solution obtains the equilibrium solution without using a time-marching method. After the direct solution method has been developed, its accuracy, efficiency, and convergence properties are studied using representative model problems.

Progress and results

The formulation of the new direct solution method has been completed. A novel matrix-partitioning procedure has been developed which effectively embeds the governing equations for the structure into the governing equations for the fluid dynamics. This matrix partitioning procedure reduces the computer time and memory requirements by an order of magnitude for two-dimensional problems.

The analysis has been demonstrated for a representative model problem. The flow in a two-dimensional, transonic, convergent-divergent nozzle with flexible walls was computed. The steady, two-dimensional, Euler equations were used as the governing equations for the fluid flow. A finite-volume approach was used, with Roe's flux difference vector splitting. A simple discrete spring model was used to represent wall flexibility. The deformation of the wall was linearly related to the difference between the local internal wall pressure and a reference pressure, taken to be the exit static pressure.

Calculations were first performed with rigid walls in order to validate the direct solver for the basic fluid dynamics. The agreement between the analysis and the experimental data was very good, and convergence was typically achieved in 5 iterations or less.

Next, calculations were performed with flexible walls. Figure 1 presents a comparison of the wall pressure ratio with and without wall flexibility. A comparison of the convergence histories obtained with and without wall flexibility is shown in Fig. 2. Wall flexibility slows convergence, but the residual is still reduced to machine zero in approximately ten iterations.

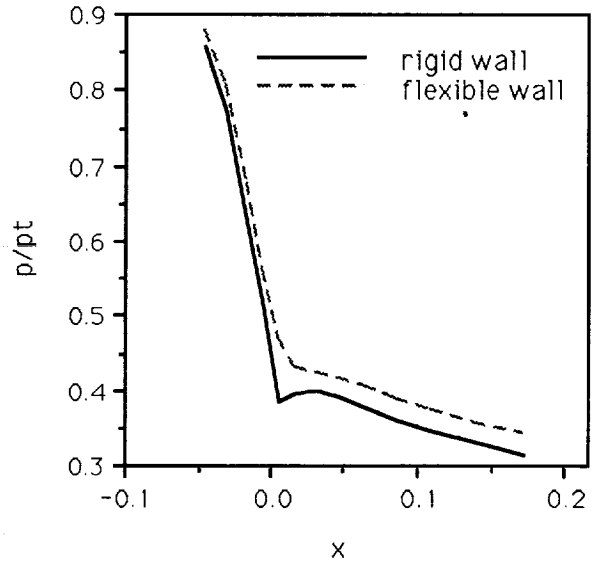

Figure 1. Comparison of predicted wall pressure ratio with rigid and flexible walls.

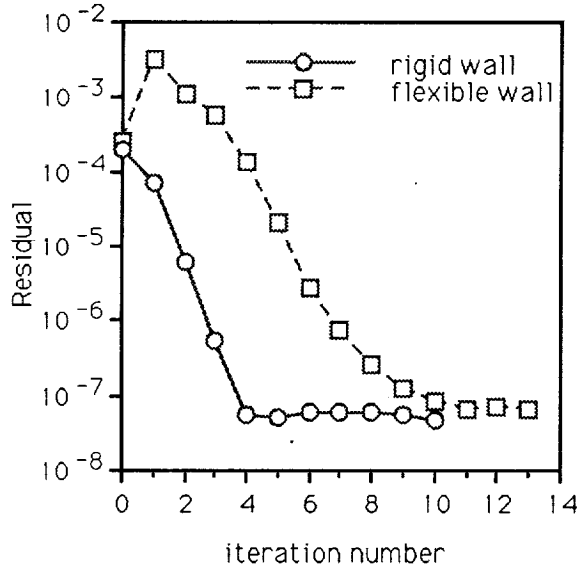

Figure 2. Comparison of convergence history with rigid and flexible walls.

Significance of the results

The direct solution approach has been demonstrated to be a viable alternative to the traditional time-march procedure. The direct solution technique provides converged results in 10 iterations or less. Conventional techniques for static aeroelasticity problems can require hundreds or thousands of iterations to achieve convergence. Also, the use of Newton's method allows for new capabilities, including the straightforward addition of new physical phenomena into the model, or optimization of the aeroelastic system.

Publications resulting from study

Felker, F. F.: "Fully-Coupled Structural Deformations and Computational Fluid Dynamics: Direct Solutions Using Newton's Method," Proc. of the 4th International Symposium on Computational Fluid Dynamics, Davis, California, September 1991.

Immunological Effects of Gravitational Stress and Simulated Microgravity

Investigator(s)
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Other personnel involved
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Objectives of the study

Our prior DDF research demonstrated that flow cytometry and monoclonal antibody technology provided a reproducible and sensitive way to monitor cellular indices of immune function in healthy ambulatory men.

The current research goal was to extend this technology to assess the impact of postural (orthostatic) gravitational stress and bed rest simulation of spaceflight on the immune system. This is the first time these techniques were applied to our –6° bed rest model in the Ames Human Research Facility. Ultimately, such research is necessary to develop a reliable ground-based model for the immunological adaptation to spaceflight and to test systematically the hypothesis that spaceflight alters or suppresses the immune system.

Rationale

Results from animal and human spaceflights suggest varying degrees of immuno-suppression, from depletion of lymphocytes to altered lymphocyte function and diminished cell-mediated delayed-type hypersensitivity. These immune system changes may compromise defenses against bacterial and viral infections as well as cancer.

However, interpretation of flight results is difficult due to diverse methodologies, small subject numbers, and variable flight conditions. Also, most astronaut and animal samples were collected or evaluated in the postflight period *after* the stresses of re-entry acceleration and landing. Immune function will become increasingly crucial for astronaut health during prolonged space exposures and crew confinement in a closed environment during Space Station, Lunar, or Mars missions. A reliable technique is required to serially monitor such changes and increase scientific understanding of the immunological adaptation to long duration spaceflight.

Methods

Details of methods used in the investigation follow.

Subjects

Ten healthy men aged 35 to 50 years who were participating in an ongoing study "Preventing Orthostatic Hypotension Resulting from Headdown (6°) Bedrest by Plasma Volume Expansion" (H.R. 77, Dr. Joan Vernikos, Principal Investigator). Subjects were selected for HR77 because of their demonstrated propensity for fainting (orthostatic intolerance) after prior bed rest microgravity simulation.

Protocol

1. Effect of gravitational stress (standing) on the immune system: Prior to bed rest (BR), blood was obtained during the recumbent control position (after 30 minutes of quiet rest, and again following 5 minutes, and finally 15 minutes in the standing position).
2. Effect of 7 days of BR on the immune system: Blood was also obtained from resting subjects for flow cytometry analysis during day 7 of –6° bed rest. Results were compared to the recumbent control position Pre BR sample.

Flow cytometry

Monoclonal antibody staining (Becton Dickinson IMK Plus Kit™) of the buffy coat from EDTA blood from each subject followed by flow cytometry (BD FACSCAN™) provided the breakdown of White Blood Cell (WBC) proportional components as follows:

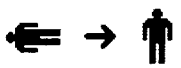
White blood cell differential	Lymphocytes	Total T lymphocytes
Neutrophils	Natural killer cells	Activated T cells
Monocytes	B cells	Helper-inducer cells (CD4)
Lymphocytes	T cells	Suppressor-cytotoxic cells (CD8)
		Helper/ suppressor ratio

Statistical analyses were done using repeated measures ANOVA throughout the Stand Test or from PreBR to BR, followed by appropriate post hoc paired comparisons with each subject as his own control.

Results

Table I shows summary results for the Stand Test and Bed Rest exposure, and details follow.

Table 1. Summary results of stand and bed rest

STAND	-6° BED REST
	
H / S RATIO ↓*	H / S RATIO ↓ (trend)
HELPERS ↓ (*at 15 min)	HELPERS ‹ › (no Δ)
SUPPRESSORS ‹ ›	SUPPRESSORS ↑*
TOTAL T CELLS ↓*	TOTAL T CELLS ‹ ›
B CELLS ↓*	B CELLS ↑ (+39%)*
LYMPHS (DIFF) ↑(*at 15 min)	LYMPHS (DIFF) ↓
MONOS ↓*	MONOS ‹ ›
NEUTROPHIL'S ‹ ›	NEUTROPHIL'S ‹ ›
NATURAL KILLERS ↑*	NATURAL KILLERS ↑
ACTIVATED T 's ‹ ›	ACTIVATED T 's ‹ ›

*P < 0.05 supine vs stand, or PreBR vs BR

Pre BR stand test

Standing produced progressive significant changes in some circulating immune cell populations after only 15 minutes in these male "Fainters." Notably, the Helper/Suppressor lymphocyte ratio (H/S ratio or CD4:CD8), a frequently used index of immunological health and prognosis in AIDS patients, progressively decreased over the course of standing (fig. 1). This was primarily due to the decreased proportion of Helper T cells. Although the H/S ratio decrease was statistically significant, the mean ratio itself remained in the normal range >1.0. The progressive pattern of change visible as early as 5 minutes of standing characterized other significant cell population decreases for total T lymphocytes, total B lymphocytes and monocytes, and increases for natural killer (NK) cells.

Bed rest

After 7 days of -6° head down BR, analogous to a Shuttle flight, circulating Suppressor T lymphocytes increased significantly by 25% ($p = 0.034$) over PreBR levels (fig. 2). Helper T cells were unchanged. The net effect was a decrease of the Helper/Suppressor lymphocyte ratio in 6 of 10 subjects, although the group mean ratios were not statistically lower (–14%, ns) after BR. The general lymphocyte fraction of WBC decreased in 8 of 10 subjects (group mean –12%, ns). The proportion of B lymphocytes increased significantly by 39% ($p = 0.043$) after BR. NK cells increased in 7 of 10 subjects (+29%, ns).

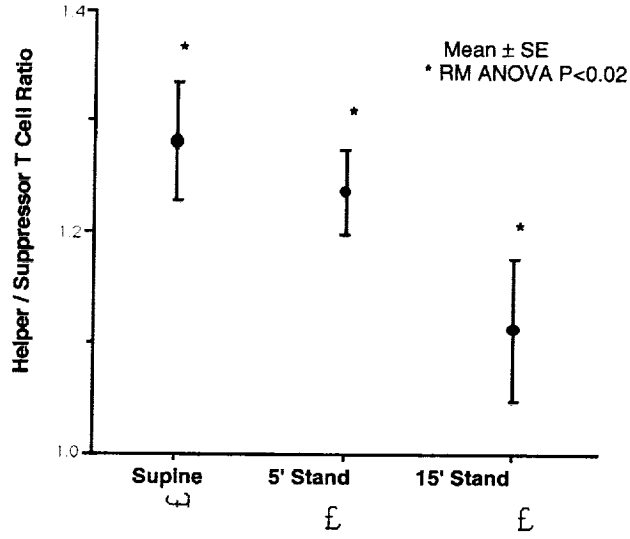


Figure 1. Effect of standing on Helper/Suppressor ratio.

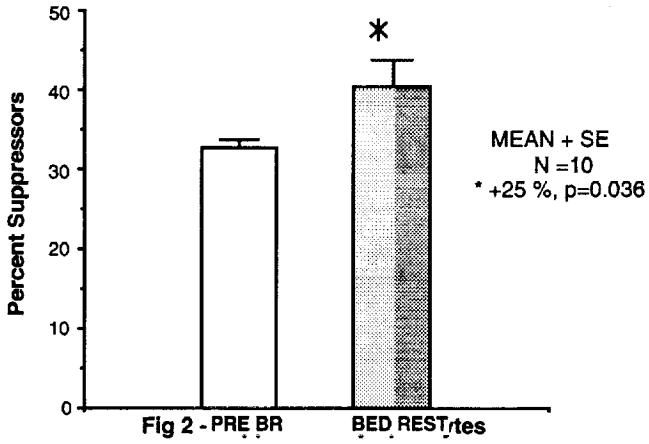


Figure 2. Suppressor lymphocytes.

Summary and Significance

- This research demonstrated the sensitivity and reliability of flow cytometry technology to detect subtle transient, progressive changes in immune cell populations during 15 minutes of standing, as well as changes after 7 days of bed rest simulation of microgravity in the Ames Human Research Facility. These results are important for development of a reliable ground-based research model of the immunological adaptation to spaceflight.
- Since whole blood was not available, we developed a technique for use of residual white blood cells ("buffy coat") from the "throw away" portion of the sample remaining after plasma harvesting. This technique should be useful for blood sampling and analysis in the microgravity or office environment when blood is limited.
- The change from the recumbent to the standing position in this group of otherwise healthy "Fainters" progressively altered proportions of circulating immunocytes over the course of 15 minutes.
- These changes may reflect the importance of neuroendocrine influence (catecholamines, corticosteroids) on the immune system, especially in these men with demonstrated cardiovascular and autonomic lability.
- The rapidity of this response suggests that this system is more labile than previously thought. Caution is therefore necessary before attributing spaceflight immune system changes to microgravity rather than the gravitational stress of re-entry.
- The response of the immune system to bed rest was qualitatively different from the response to orthostatic stress.
- After 7 days of bed rest simulation of microgravity, both Suppressor T lymphocytes and B lymphocytes significantly increased. The tendency for NK cells to increase in both conditions may reflect a nonspecific stress response.
- These results are consistent with some of the previous spaceflight and simulation results. Increased B and NK cells have been seen in cave isolation studies and in Soviet rat and human space studies. The finding of elevated Suppressor T cells after BR is consistent with the decrease in delayed type cell mediated immunity reported from U.S. flights.
- Decreased cell mediated immunity induced by bed rest alone may contribute to opportunistic infections or delayed recovery in some patients who are traditionally treated with bed rest or hospital confinement.
- Studies such as this enhance understanding of immune system responses to autonomic or orthostatic stress and to bed rest inactivity, with possible implications for insight into immunosuppressive disorders (such as AIDS) and interpretation of tests used for serial monitoring of immunosuppressed patients. For example, these results suggest that patients should be positioned in a standardized manner prior to each blood draw for serial prognostic or therapeutic Helper/Suppressor (CD4/CD8) ratio monitoring.
- We hope to confirm and extend these results in future studies.

Initiating a Model System Using Skin Cells to Study Spaceflight-Related Aging and Senescence

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Other personnel involved
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Patrick Suen,* Stanford University, Stanford, CA

Objectives of the study

Observation of mammalian cells during and after exposure to spaceflight conditions has revealed changes in metabolism, proliferative cycling, and growth factor responsiveness similar to changes characteristic of senescent cultured cells at 1-g. Cells termed senescent may have expended their replicative potential through extensive passage *in vitro*; may be derived from chronologically aged individuals; or may be isolated from patients with advanced aging disorders. Werner's syndrome is one such disorder, and exhibits nearly all the phenotypic and biochemical markers of aging, with the notable exception of neurologic degeneration and senility. Many of the clinical symptoms of this disease relate to the skin and connective tissue.

In culture, dermal fibroblasts from Werner's syndrome patients demonstrate altered expression of the gene collagenase I. Collagen represents the single most important connective tissue macromolecule, and makes up 90% of the dry weight of the dermis. Collagen remodeling (to accommodate growth and wound repair) and removal (in degenerative joint conditions) is accomplished through the activity of collagenase I, a matrix metalloprotease. Werner's syndrome fibroblasts constitutively over-express this enzyme, and yet fail to respond to normal inducers of its synthesis. As the disease is an autosomal recessive genetic disorder (implying a single underlying mutation), understanding the cause of this abnormal regulation of collagenase could be central to the pathology of both Werner's syndrome and normal aging. The limited data available on the behavior of mammalian cells cultured in space indicate many similarities between senescent cells and spaceflight-grown cells. The model of Werner's syndrome fibroblasts *in vitro* was investigated to further decipher the root causes of senescence, and to permit prediction of the responses of cells and (potentially) humans to spaceflight-related stresses.

Progress and results

During the first year of these studies, we examined the hypothesis that the failure of Werner's syndrome fibroblasts to respond to growth factors resulted from a primary defect in the recognition sequences of the hereditary material (DNA). Normal recognition sequences were introduced into these cells and into appropriate young and aged control cells using recombinant DNA techniques. A functional assay was used to determine the response of the cellular machinery to these externally supplied sequences. The Werner's syndrome cells were persistently unresponsive, while both young and aged controls responded normally. We concluded that the defect of Werner's syndrome did not lie in the primary sequence of this recognition element. However, parallel experiments indicated that other components of the signal transfer system were unusually regulated in this disease.

We initiated a study of these components. Growth factors normally interact with receptors at the cell membrane. The occupied receptor then signals the presence of the growth factor via a cascade of internal chemical and enzymatic mediators. In Werner's syndrome, the receptors for the particular growth factor under study, platelet-derived growth factor (PDGF), appear normal in number and affinity for ligand. They initiate the first reaction in the signal transfer pathway, but the signal is not received in the nucleus by the hereditary material. As indicated above, the original hypothesis stated that the signal was not received due to a mutation in the control recognition sequences. This hypothesis proved untenable. However, we discovered abnormal levels in Werner's syndrome cells of two proteins, *c-fos* and *c-jun*, which combine to form the recognition factor controlling the collagenase I gene.

In the second year, we extended our studies to a different pathway regulating collagenase I expression. Collagenase I, and the entire matrix metalloprotease gene family, can be suppressed by glucocorticoid treatment. This effect, in addition to the induction of enzyme by the growth factor PDGF, is caused by interactions between nuclear factors and DNA recognition elements. To further pinpoint observable defects in Werner's syndrome cells, we investigated the pathway of hydrocortisone suppression of collagenase I

*Summer pre-med student interns supported by this project.

synthesis. Results show that, unlike the PDGF inductive pathway, the hydrocortisone suppressive pathway operates apparently normally in Werner's syndrome and aged cells. Interestingly, Werner's syndrome fibroblasts synthesize, as a baseline, up to ten times the normal amount of collagenase I, yet they are more sensitive than normal cells to hydrocortisone shutdown. Synthesis of collagenase I was reduced 79-92% in hydrocortisone-treated Werner's syndrome cells, versus a repression of only 56-58% in aged normals.

We developed one unusual result. PDGF normally induces collagenase I expression, while Werner's syndrome cells are unresponsive. However, Werner's syndrome fibroblasts pre-treated with hydrocortisone, then exposed to hydrocortisone with PDGF, showed additive suppression (18-52%).

Significance of results

Werner's syndrome, in addition to the biochemical phenotype of excess collagenase I synthesis, is characterized by chromosome breakage. Many, but not all, of these breakage events have been observed near the collagenase I gene on the long arm of chromosome 11. The DNA, or hereditary material, is normally maintained in a condensed and protected structure. It is unwrapped piecemeal during DNA replication; portions are unwrapped as needed for the expression of selected genes. One could speculate that breakage of the DNA locale at the collagenase I control recognition sequence unwraps this area, allowing for increased sensitivity to interactions with nuclear factors. This might occur in addition to a defect involving inappropriate regulation of the nuclear factors *c-fos* and *c-jun*. Recently, Kerppola and Curran (Cell 66:317-326, 1991) reported that binding of Fos:Jun heterodimers bends the DNA in a different fashion than does binding by Jun:Jun homodimers. The Fos:Jun configuration is favored; however high protein concentrations of Jun result in the production of the homodimer moiety. Aberrant regulation of the quantities of *c-fos* and *c-jun* messages, which would lead to unusually high levels of Jun, were our findings in the Werner's syndrome cells.

As mentioned above, similarities between Werner's syndrome cells and spaceflight-exposed mammalian cells, chronologically aged cells, and cultured senescent cells suggest the value of Werner's syndrome as a model system. Furthermore, the accessibility of skin tissue by relatively noninvasive procedures enhances the attraction of dermal cell systems. In Werner's syndrome, we find a cultured cell model with several defined anomalies and a single underlying genetic defect. Current techniques allow indepth study of both the expressed abnormalities and the DNA defect.

Results indicate the general utility of this model for studying hypotheses related to spaceflight effects on mammalian systems. In addition, our results have added significantly to an understanding of the relationship between gene expression and both aging and genetic disease.

Publications resulting from study

Presented papers:

R. A. Grymes, Regulation of the collagenase I gene in Werner's syndrome, Western Regional Meeting of the Society for Investigative Dermatology, Feb. 1991.

R. A. Grymes, Type I collagenase gene regulation in Werner's syndrome fibroblasts, National Meeting of the Society for Investigative Dermatology, May 1991.

R. A. Grymes, Platelet-derived growth factor signal transduction in fibroblasts of an aging disorder: Werner's syndrome, Gordon Conference on Biological Structure and Gene Expression, July 1991.

Abstracts and papers:

Grymes, R. A.; Chan, J.; Suen, P.; and Bauer, E. A.: Regulation of the collagenase I gene in Werner's syndrome, Clinical Research, vol.39, no. 1.

Grymes, R. A.; Chan, J.; Suen, P.; and Bauer, E. A.: Type I collagenase gene regulation in Werner's syndrome fibroblasts, Journal of Investigative Dermatology, vol. 96, no. 4, p. 539.

Altman, J.; Chan, J.; Grymes, R. A.; and Bauer, E. A.: Collagenase expression in progeroid fibroblasts: Hydrocortisone suppression (submitted to Clinical Research), Oct. 1991.

Grymes, R. A.; Altman, J.; Chan, J.; Suen, P.; Vernikos, J.; and Bauer, E. A.: Induction and suppression of collagenase I synthesis in a progeroid cell strain (manuscript in preparation).

Domain Decomposition Approach to Solve Multidisciplinary Fluid/Structure Interaction Problems

Investigator(s)
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Objectives of the study
Develop efficient interfacing techniques between fluid zonal grids and structural sub-domains (sub-structures). These new interface techniques will be tested on simple model problems. Procedures to use this development to solve larger three-dimensional problems associated with complex geometries, such as full aircraft, will be addressed at the end of this research.

Progress and results
During this period, interfacing techniques are developed for wing-type configurations. The flow is modeled using the finite-difference (FD) method with a single C-H type grid. The structural properties of the wing are modeled using a finite-element (FE) wing-box-type model in which the surface of the wing is modeled using triangular membrane elements. An interfacing routine to transfer information from FD fluid's grid to FE structural grid is developed. The procedure is demonstrated by computing thermal stresses of a wing at supersonic flow conditions. This demonstrates the use of the present development for configurations that can be modeled using single zones.

Significance of the results
The present results demonstrate the application of the basic idea of interfacing the information between FD fluid grids and FE structural nodes for wings. This will serve as a stepping stone to the domain-decomposition approach for complex configurations. This work will be extended for wing-body configurations with two sub-structures, one for the wing and another for the body. First, results will be demonstrated for a single-zone FD grid and two-zone structural FE model. Then they will be extended for a two-zone FD grid, and aeroelastic computations will be made for a typical flexible wing-body configuration.

Publications resulting from study: None so far

References: None so far

An Iterative Image Rectification Scheme for Observational Astronomy

Investigator(s)
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Steven D. Lord, University of California, Santa Cruz, CA

Other personnel involved
Michael Werner, SIRTF Project Scientist, Jet Propulsion Laboratory
James H. Ramberg, Physics Graduate Student, San Francisco State University, San Francisco, CA

Objectives of the study

The objective is to explore the use of a numerical image rectification algorithm which has the ability to enhance the spatial resolution of astronomical images. This algorithm, the Richardson-Lucy Maximum Likelihood algorithm, can be used to sharpen images by removing the blurring effects of a telescope's aperture.

In a specific application, we have used this algorithm to correct the "double images" that will result as part of future Space Infrared Telescope Facility (SIRTF) polarimetry measurements. The double images are caused by use of a Wollaston Prism, an otherwise advantageous polarization measuring device which allows for time-efficient observations. Extraction of the polarized information requires rectification of the focal plane image. We have assessed the feasibility of the numerical image reconstruction technique to post-process the polarimeter's output and recover the image polarization information.

Progress and results

In this project, we have performed simulations and gauged the performance of the algorithm with respect to variations in important astrophysical parameters such as: spatial resolution, signal to noise, and degree of polarization of the input data. We used the algorithm to reconstruct images that were based partially upon test distributions of polarized emission and also on actual far-infrared astronomical polarimetry observations of the Galactic Center and the Orion Nebula. The algorithm was implemented on a VAX 8600. In all cases convergence was reached after about 200 iterations. The figure shows the algorithm acting on a "double image" of the Galactic Center, observed at a wavelength of 100 micrometers. The reconstruction successfully retrieved the polarization angle and flux at each pixel, to about 1%.

Significance of the results

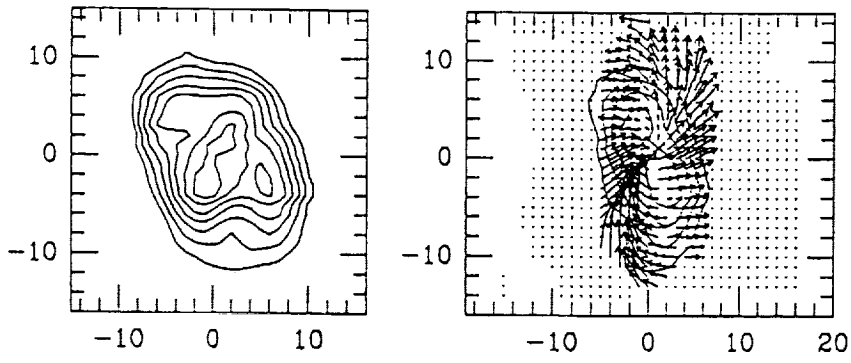
When this project was initiated two years ago, it was predicted that algorithms such as the Richardson-Lucy algorithm would prove very useful in improving astronomical images. Currently the algorithm is demonstrating its utility as the premier algorithm for correcting the Hubble Space Telescope images for distortion due to spherical abberation. We have also demonstrated its usefulness in reconstructing SIRTF images, allowing for time-efficient polarimetry. Further applications include spatial resolution enhancements of spectroscopic maps.

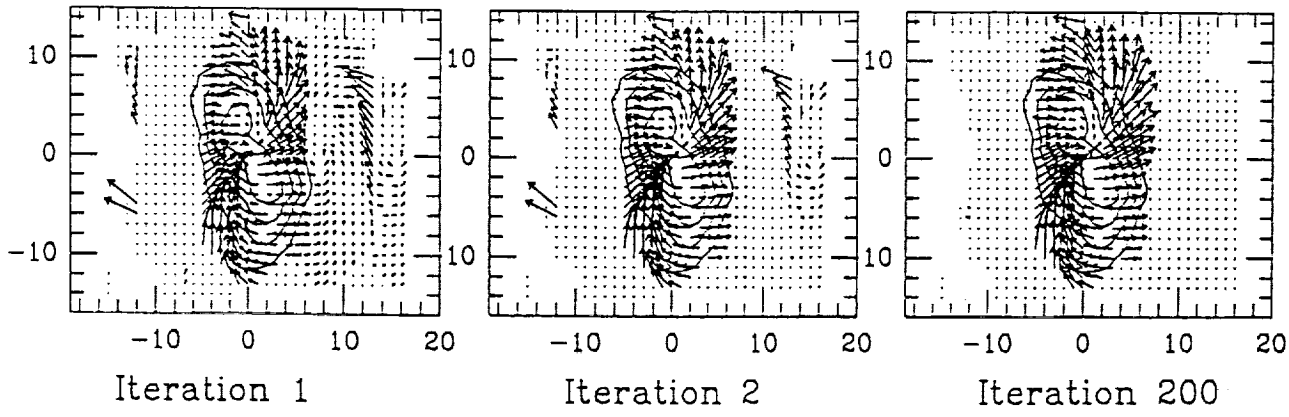
Publications resulting from study

S.D. Lord, J. H. Ramberg, and M. Werner (1991) "MIPS Polarimetry: Considerations in Using a Wollaston Prism for Extended Source Observations," SIRTF Polarimetry Working Group Report.

References

The Restoration of Hubble Space Telescope Images and Spectra, (1990) Proc. of the Space Telescope Science Institute Workshop, Baltimore, Editors: R. L. White and R. J. Allen.





The Galactic Center at 100μm

The "double image" of the Galactic Center shown in the top left frame above was used as a test distribution for the Richard-Lucy algorithm. In the top right frame, the true intensity and polarization field are shown, where the length of a vector indicates the degree of polarization.

Iterations 1, 2, and 200 of the Richardson-Lucy algorithm are shown below. The reconstruction converges at a rate proportional to the magnitude of the smallest fluctuations in the image. In situations like this, where the data have a large dynamic range, many (200) iterations are required. Final intensity errors of 10^{-6} are accompanied by polarization errors of 10^{-2} in this test. Some of these errors can be seen as non-zero vectors in the lower left in Iteration 200.

Remote Sensing of Earth's Atmosphere and Surface Using a Digital Array Scanned Interferometer

Investigator(s)
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William Hayden Smith, Washington University, St. Louis, MO

Objectives of the study

Understanding complex and variable environmental phenomena inherent in Earth's atmosphere, global climate, and biogeochemical processes requires spatial, spectral, and temporal observations which are both extensive and detailed. Thus the motivation is clear for designing simple, versatile, and cost effective imaging spectrometers for Earth remote sensing applications with high spatial and spectral resolution, fast temporal response, and high detection sensitivity.

The primary objective of our study is to evaluate the capabilities of the DASI (digital array scanned interferometer) class of instruments for measuring terrestrial radiation fields, particularly in the visible to mid-infrared. DASIs have much potential as future generation remote sensing instruments. They are capable of high throughput, sensitivity, and spectral resolution, and have the potential for field-of-view spatial discrimination (an imaging spectrometer). The compactness, low weight, power economy, and simplicity of design and operation of DASIs make them particularly suitable for ground and airborne platform-based remote sensing. DASIs show promise of overcoming some of the shortcomings of equivalent aperture grating-based imaging spectrometers such as FLI, ASAS, AIS, and AVIRIS.

The ultimate objective stemming from this study is to produce and deploy a versatile field instrument which may be applied toward a variety of atmospheric and surface problems.

Progress and results

Below is a summary of our first year's progress, covering developments in hardware and software engineering, data reduction and analysis procedures, development of science strategies and collaborations, and plans for participation in future field experiments. Benchtop laboratory testing and measurements using a DASI with a common path configuration have been made at Washington University, St. Louis, Missouri, and Ball Aerospace, Boulder, Colorado. Engineering data was acquired with both CCD and experimental NICMOS (1-2.5 micron sensitivity) two-dimensional detector arrays. Progress with optics ray tracing software for simulating DASI operation has been made. Such simulations are essential for determining and optimizing the design in order to fully realize the potentials of DASIs.

Analysis software is under development for DASI cube-type images. An atmospheric optical path simulation software package, MODTRAN, is now operational. MODTRAN, together with radiative transfer software incorporating the scattering and absorption effects of clouds, is aiding the planning of experiments and the simulation of future measurement analysis.

A science plan for field observations of clouds using a DASI was developed as a result of preparing a proposal to the NOAA Global change program. The application of DASIs for remote sensing of plant biochemical content is being studied and opportunities such as the Biome sensor (being formulated at NASA Ames) are being explored.

Laboratory work with our university collaborator, Wm. H. Smith, has begun at Ames, and a DASI prototype is under construction for field observations. We have initiated a collaboration with an atmospheric lidar group for informal participation in project FIRE, which could yield coordinated multi-sensor measurements of cirrus clouds leading to a case study.

Significance of the results

The engineering data have revealed that the best choice of DASI optical configuration is a common path interferometer. That configuration is characterized by its stability and absence of critical sensitivity to alignment, although it is less capable of achieving high spectral resolution. Since the science problems of most interest to us in the near term involve the spectroscopy of condensed phase matter, low resolution is adequate.

In formulating our science plans, we determined that the visible to 2.5 micron spectral region is of key value for future planned field studies because of ready availability of detectors, relative ease of operation, and high potential for science yields. A specific approach for retrieving information about clouds from spatially and spectrally (1-2.5 micron) resolved measurements of the solar aureole is being explored. The possibility of contributing to a coordinated multi-sensor case study of cirrus clouds (FIRE) is especially promising in terms of the science yield.

Publications resulting from study

- Seminar given at Oregon State University at Corvallis, Oregon, November 1990
- Poster & abstract at Airborne Geoscience workshop, San Diego, CA, January 1991
- Discussion of DASI applications for vegetative canopy studies was presented at the Workshop on Remote Sensing of Plant Biochemical Content, Marshall CA, March 1991
- Article on DASI potentials and applications submitted to Journal of Imaging Science, October 1991
- Abstract submitted for AGU meeting, San Francisco (to be held December 1991)

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Fault Tolerance in Distributed Parallel Processing Architectures for Flight Crucial Systems

Investigator(s)
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Ames Dryden Flight Research Facility,
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Objectives of the study
To study the fault tolerance of transputer-based networks for use in flight crucial systems.

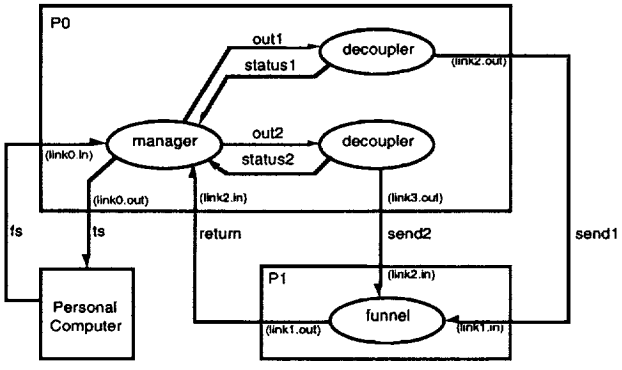
Flight systems are evolving into sophisticated, integrated systems that require substantial computational power. Parallel processing is one way to provide that power. A distributed architecture has potential advantages of fault tolerance and facilitated expandability.

The transputer is a state-of-the-art 32-bit microprocessor with a multitasking kernel specifically designed for parallel processing. Transputers have four high-speed serial communication links which allow them to be networked without a common bus. Hence they are well suited for distributed architectures and have potential reliability advantages.

Progress and results
The work is now complete at the DDF level. The research has been successful, and followon research objectives have been identified.

The research explored the fundamental principles associated with fault tolerance of transputer networks. Code was written in occam, a parallel processing language for which the transputer was specifically designed. More common language compilers exist for the transputer but were not used in this research. The network topology studied is shown in the diagram.

NETWORK TOPOLOGY



Note: Processors P0 and P1 are drawn as different sizes only for clarity in this drawing. They are in actuality identical processors, both T800s.

The network consists of two 25 MHz T800 transputers and a Personal Computer (PC). The PC is used solely for keyboard interface and display. The network runs four processes in parallel: three on processor 0 (P0) and one on processor 1 (P1). The two transputers are connected to each other by three links: two redundant links from P0 to P1 and one from P1 to P0. It is the tolerance to the failure of one of the redundant links that has been explored specifically.

Key discoveries
1. One way to make the network tolerant to link failures is to decouple the intertransputer communications from other processor functions.
2. An acknowledgement from the decoupler to the manager is required.
3. The ALT construct facilitates management of a failed link from the side of the receiving process.
4. The ALT construct must be nested in order to give all communications the opporunity to finish.

More on the key discoveries
In transputers, communications do not proceed until both the transmitting and receiving processes are ready. Thus, without protection, the two processes would find themselves in suspended animation, i.e. hanging, in the event of a link failure. Two sets of techniques are used to provide fault tolerance: one for the transmitting end and one for the receiving end.

On the transmitting end, the principal process, the manager in this case, is protected from link failures by scapegoats called decouplers. The manager passes information to the funnel through the decouplers. In the event of a link failure, the decoupler hangs and the manager continues unharmed. For the decoupling to work properly, the decoupler must provide an acknowledgement to the manager. The manager detects link failures by the absence of this acknowledgement.

For the receiving side, occam comes with a construct called the alternation (ALT). Within this construct only one process is required to finish for the entire construct to finish. Use of the ALT construct in a nested fashion gives opportunities for all redundant communications to finish while providing immunity from link failures.

Significance of the results
Transputer-based networks appear to be viable platforms for flight crucial systems. The exploration of

fundamental principles associated with the fault tolerance of transputer networks resulted in four key discoveries. Processes on the transmitting end of a communication link can be made tolerant to the failure of that link by using a decoupling transmission process. Processes on the transmitting end of a communication link can be made tolerant to the failure of that link by using the ALT construct with timers.

Transputer-based networks have the advantage of straightforward reversion from primary links to secondary links. Because of the parallel processing nature of the transputer, system throughput is not degraded by redundancy management.

The successes of this research indicate that transputer-based networks show promise for flight crucial applications.

Development and Experimental Verification of a Noninvasive Intracranial Pressure Recording System

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Objectives of the study

Headaches and space motion sickness commonly reported during exposure to microgravity may be a consequence of or exacerbated by increased intracranial pressure (ICP). Recent studies document increased ICP in rhesus monkeys exposed to simulated microgravity, as modelled by 6° head-down tilt (HDT). The invasive nature of ICP techniques has prevented basic studies involving the measurement of this variable in humans. The objective of this study, therefore, was to develop and test a noninvasive technique to examine alterations of ICP during acute 6° HDT in humans.

Although the results of our initial transcranial acoustic technique were inconclusive, another noninvasive technique, tympanic membrane displacement (TMD) technique provided reliable and useful results. The TMD technique, developed by Robert Marchbanks, is based on the principle that movement of the ear drum or tympanic membrane (TM), induced by the stapedial muscle reflex, produces slight but significant volume displacements that can be measured with a special computer-based instrument. The TM is attached to three bones of the middle ear. The third bone, stapes, is in turn attached to the oval window of the inner ear. The oval window interfaces with the inner ear fluid. This fluid pressure is essentially equal to ICP due to a direct connection created by a duct. Alterations in ICP (and inner ear pressure) relate to the TM inward or outward displacements depending on whether ICP has increased or decreased, respectively.

TM displacements were measured by a volume displacement transducer probe attached to a head set. The probe was tightly sealed into the ear canal. Movements of the TM, and hence changes in ICP, were compared in various postures within each subject.

Progress and results

Compared to upright-seated posture, 0° horizontal, 6° HDT, and 15° HDT produced TMD changes of 317 ± 112, 403 ± 114, and 474 ± 112 nl (means ± S.E.), respectively (Fig. 1). Furthermore, postural transitions from 0° horizontal to 6° HDT and from 6° to 15° HDT generated significant volume changes.

Significance of the results

Our results indicate that simulated microgravity (6° HDT) increases ICP based on the relationship that exists between TM displacement and ICP. ICP increases from about 2 mm Hg to 17 mm Hg when going from upright to 6° HDT postures, respectively. Evaluation of ICP by the TMD technique depends upon a normal middle ear, intact stapedial muscle reflex contraction, and a patent duct. Although the technique does not provide absolute ICP measurements, mean TM displacement allows interpolation of ICP to already obtained normal and abnormal ICP values.

ICP is potentially a critical parameter for understanding physiological changes during actual and simulated microgravity. Increased ICP may affect middle and inner ear function and may thereby cause or augment headaches and space motion sickness in microgravity. These conditions are experienced by many astronauts during initial exposure to microgravity and adversely impact crew performance during Shuttle flights.

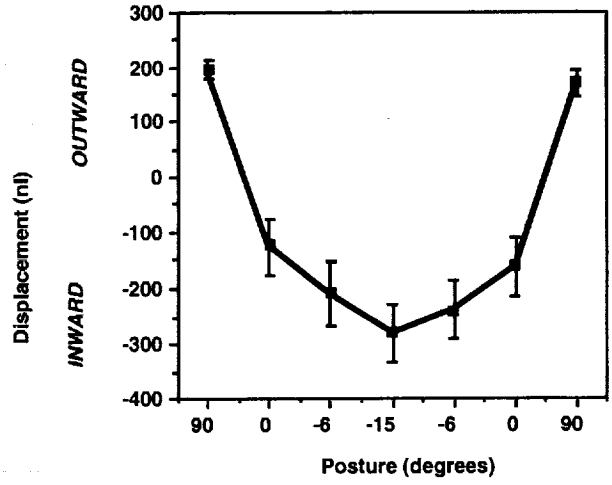

Figure 1. Tympanic membrane displacement response with various postures.

During HDT, increased blood pressure in the head elevates capillary pressure, which may be responsible for facial swelling, blood vessel distension, and increased ICP. If ICP is sufficiently high (>30 mm Hg), it may reduce brain blood flow and deprive brain tissue of nutrients, causing decreased performance in microgravity. This study of simulated microgravity should be extended to actual microgravity (KC-135 or Shuttle missions).

Publications resulting from study

1. Hargens, A. R.; Parazynski, S.; Aratow, M.; Meyer, J.-U; Crenshaw, A; and Whalen, R: Exercise and tissue-fluid shift studies at NASA Ames Research Center. Advances in Bioengineering 15:155-156, 1989.
2. Hargens, A. R.; Parazynski, S.; Aratow, M.; Meyer, J.-U; Crenshaw, A; and Whalen, R: Exercise and tissue-fluid shift studies at NASA Ames Research Center. 110th ASME Winter Annual Meeting, p. 77, 1989.
3. Hargens, A.R: Upright posture and cranial hemodynamics in humans and other "tall" animals. Commentary in behavioral and brain sciences 13:359-360, 1990.
4. Murthy, G.; Marchbanks, R. J.; Watenpaugh, D. E.; Meyer, J.-U.; Eliashberg, N.; and Hargens, A. R.: Increased intracranial pressure in humans during simulated microgravity. Transactions of 13th Annual IUPS Commission on Gravitational Physiology, San Antonio, Texas. The Physiologist 34:257(48.1), 1991.
5. Murthy, G., Marchbanks, R. J.; Watenpaugh, D. E.; Meyer, J.-U.; N. Eliashberg, and Hargens, A. R.: Increased intracranial pressure in humansduring simulated microgravity. The Physiologist 36 (supplement), 1992.

An Airborne Infrared Scanner for Wild Fire Mapping and Monitoring

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Objectives of the study

Our objective was to design and build a low cost multichannel digital scanner for monitoring the impacts of wild fire on ecosystem and atmospheric processes with potential application for fire management and mapping.

Progress and results

We have designed and fabricated mechanical hardware, electronic and computer controls, and optical components to build an infrared imaging scanner. The individual components now require assembly and testing before actual use. The scanner will provide four visible/infrared channels for gathering imagery from an airborne platform. Onboard capabilities will include real-time data display and limited image processing. Scanner parameters can be modified by an operator to adapt to different applications. Further image processing will be accomplished by using a dedicated ground facility that incorporates data processing, communications, and hard-copy production.

Interface hardware for deploying this scanner on several small aircraft exists or is being fabricated, and there is interest in mounting the scanner on the NASA C130 and ER-2 medium- and high-altitude platform aircraft. A twin-engine Navajo owned by the Los Angeles County Fire Department has been extensively modified to accommodate the scanning system. The National Center for Atmospheric Research is currently fabricating a mounting kit for their King Air research aircraft to support fire research in the United States and Brazil.

The original optical design utilized a Kennedy optical configuration but included only a single imaging channel. A new optical train has been designed and fabricated to provide up to four imaging channels spanning the visible red to the thermal infrared regions. Several novel techniques were used to modify the single channel instrument to a multi-spectral scanner. Two new detectors, a "sandwich" detector for the thermal infrared region, and an indium-gallium-arsenide (InGaAs) photodiode for the near infrared have been added. These detectors significantly reduce the space required to provide additional spectral channels. Diamond-turned aspheric optics have been used to redirect and re-collimate the incoming light, allowing multiple spectral bands to be directed to their respective sensors.

A key innovation incorporated in the new scanner is its ability to be controlled by an integral microcomputer system. Most other multi-spectral scanners do not take advantage of available computer technology to provide onboard processing and control. Our system utilizes state-of-the-art helical-scan digital tape recorder technology to record imagery in digital machine-readable form. All sensor functions are controlled by the onboard CPU, and real-time image processing and display is managed by a smart video graphics coprocessor. To facilitate deployment on a variety of airborne platforms, the scanner system includes a Global Positioning Satellite (GPS) receiver and a pitch/roll gyroscope for aircraft attitude and location sensing. Two unique capabilities being tested on this system are a new delta-sigma digitizer and a digital scan-motor speed controller. These innovations have potential for updating similar systems on Ames medium- and high-altitude aircraft.

Significance of results

While no actual flight data will be collected until spring, this instrument is an integral part of two major research efforts examining the impact of fire on terrestrial and atmospheric processes. The unique capability provided by this system is its ability to accommodate multiple aircraft platforms with few modifications.

A working coalition between three government agencies has emerged as a result of this project. Ames Research Center, the U.S. Forest Service, and the L.A. County Fire Department have provided resources and expertise for building and operating our scanner. Requests have also been noted from the University of Washington, NCAR, and EPA for use of this instrument for environmental monitoring. This instrument has also become a focal point for a NASA

commercialization program for the development of a remote sensing system for disaster assessment. This program involves not only the public, but private sector, including the state of California and Terra-Mar Resource Information Service.

Publications resulting from study

Terra Mar press release: "Terra-Mar and NASA Collaborate on Natural Disaster Assessment," Jan. 23, 1991.

Brass, J.; Hildum, E; and Riggan, P.: "Use of Remote Sensing Technology for Fire Management Applications," Proceedings of the National Fire Management Conference, Woodside, CA, May 1991.

D. Walklet, "Fighting Forest Fires With Remote Sensing," Photonics Spectra, Aug. 1991, p.66.

Intelligent Dynamic Scheduling Algorithms for Automatic Telescopes

Investigator(s)
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Objectives of the study

There are many NASA mission scenarios in which the unattended autonomous operation of a scientific instrument is desired because of the expense of an in-situ human operator. This is especially true for astronomical observations, in which the method of data acquisition is well suited to automatic operation. Automatic Photoelectric Photometry is currently performed with ground-based robotic telescopes at various sites around the world. These robotic telescopes perform unattended photometric measurements of stars for periods ranging from weeks to months, scheduling their observations from target lists and priorities decided ahead of time by astronomers.

Although robotic telescopes are currently in operation, they are not very sophisticated with respect to efficient target scheduling, health monitoring, or self-maintenance. While these capabilities are desirable for ground-based operation at easily accessible sites, they are critical for operation in space or other relatively inaccessible sites. This project is an attempt to transfer current state-of-the-art technology in the areas of intelligent scheduling and health monitoring to the operation of automated telescopes. It is a collaborative effort between individuals and groups working in telescope design and control, intelligent scheduling, health monitoring and fault diagnosis, and astronomy.

Progress and results

- Developed a high fidelity Automatic Photometric Telescope (APT) simulator, designed to allow the in-house development and testing of advanced planning and scheduling control software.
- Developed a prototype Interactive Scheduling Tool, which was put to immediate use in preparing the fall 1991 observing schedule for an operating APT.

Future plans

1992: Benchmark performance increase in the use of new scheduling algorithms in existing simulated control systems. Hold workshop on the testing of an autonomous telescope in Antarctica as a Lunar mission precursor.
1993: Apply scheduling algorithms to field use and measure their performance. Acquire an automatic telescope locally for fault diagnosis and health monitoring research.
1994 and beyond: Implement an Antarctic-based robotic telescope as a Lunar mission precursor.

Publications resulting from study

1. "Development of a Simplified Operations and Management Structure," B. Hine and R. Genet, 1990 Workshop on Small Robotic Telescopes on the Moon.
2. "The APT Planning and Scheduling Manifesto," M. Drummond, J. Bresina, K. Swanson, A. Philips, and R. Levinson, 1991 NASA ARC Technical Report #FIA-91-24, in preparation.
3. "Multi-Use Lunar Telescopes" R.M. Genet, D. R. Genet, D. L. Talent, M. Drummond, B. Hine, L. J. Boyd, and M. Trueblood, to appear as a chapter in the ASP Conference series book Robotic Telescopes in the 1990s, A. Filippenko (ed).

Control of Thermal Simulation Tests with Heat Flux

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Objectives of the study

The objective of this study is to develop the ability to use heat flux sensors for data acquisition in and control of thermal simulation tests in the Thermostructures Research Facility (TRF) and Liquid Hydrogen Structures Research Facility (LHSTF) at Ames Dryden Flight Research Facility. Direct measurement of heat flux is required when testing many advanced structures such as cryogenic fuel tanks and actively cooled structures. Actively cooled structures will be tested by varying the heat absorbed by the structure while the cooling system keeps the structure at a relatively constant temperature. This eliminates the possibility of using temperature measurements in the feedback control loop of the heating system as is currently done.

This study will define minimum specifications for use in future purchases of heat flux sensors for various test articles. These specifications will include particular types and models of heat flux sensors well suited for use in given temperature and/or heat flux ranges. The study will also result in the development of systems and procedures required to calibrate heat flux sensors for use in the TRF and LHSTF. Onsite calibration is critical for heat flux sensors used in the control loop during hazardous tests such as those conducted in the TRF and LHSTF. Data acquisition and control system hardware and software modifications required in order to use heat flux sensors will also be identified and implemented.

Progress and results

Progress to date includes the completion of low temperature (<500° F) heat flux gage tests and the initiation of high temperature (<1600° F) heat flux gage tests with the pulsed radiant heating system used in the TRF and LHSTF. A furnace for use as a heat flux gage calibration system has been delivered and acceptance tests have been completed. Open loop heat flux control has also been established permitting tests to be performed independent of temperature time histories.

Initial test results show that the pulsed radiant heating system utilized in the TRF and LHSTF may not cause severe problems in controlling to a heat flux profile. The amplitude of the variations caused by the pulsed heating are much less than the heat flux increment between heating power levels. This could reduce the need for different heating power controllers or smoothing algorithms in the control software.

Initial tests have also resulted in the identification of several heat flux sensors well suited for use in the TRF and LHSTF. Several such sensors will be used during tests of the Generic Research Cryogenic Tank in late 1992.

Testing to date of water cooled heat flux sensors indicates that they sense heat from the structure reflected by the heater reflector. This gives a false high reading of heat flux as the structure temperature exceeds that of the heat flux sensor. It may be possible to correct for this effect, but sensors which operate at the same temperature as the structure are more desirable. Cooled gages may be required in order to test advanced structures, such as those manufactured from carbon-carbon, above the useful operating temperatures of currently available sensors.

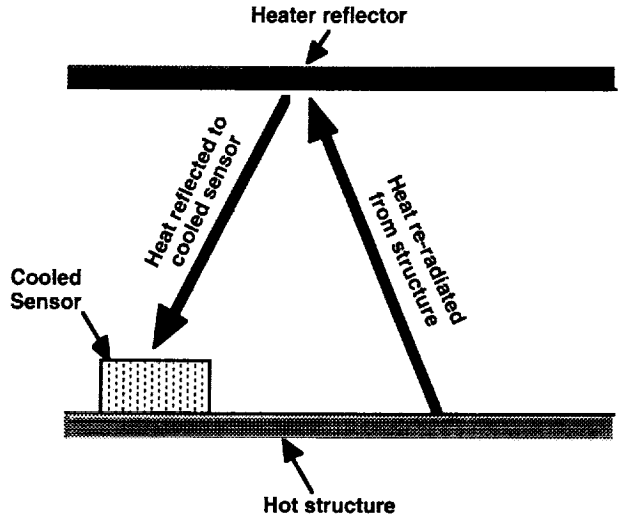

Figure 1. Heat reflection to cooled sensor.

Development of a Si(Li) Gamma Ray Detector Stack for Future Mars Mission Instruments

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Objectives of the study

Develop, test, and compare to numerical model predictions, a novel lithium-drifted Silicon [Si(Li)] gamma ray detector package. A large-scale, flight version of this detector package would be a key element in an elemental measurement instrument for future Mars missions. Use of Si will allow operation at ambient Mars temperature, an enormous advantage when compared to proposed germanium gamma ray detectors which require cooling to ~100K. Development of this detector package would provide high resolution detection of gamma rays with energies in the million electron volt (MeV) range, a unique accomplishment for Si(Li) devices. During the DDRF research effort, we fabricated and tested a Si(Li) detector stack consisting of approximately 4-5 planar Si(Li) detectors each 5 mm thick. Testing was conducted as a function of temperature, with special attention to Mars ambient at the Viking Sites. Results were compared to a Monte Carlo model which predicts the spectral peaks resulting from gamma ray interactions with Silicon.

Progress and results

In order to improve the peak-to-background ratio, we employed an anti-coincidence technique which we have labeled the "split-stack" procedure. Figure 1 shows a cross section view of the experimental setup of the detector stack. The signals from the amplifiers are summed as though the stack were continuous. The outputs are also routed and converted to digital signals which are checked for coincidence within a certain time window. If this criteria is met then the output is fed into the ADC unit and acts as a gate signal, and the summed signal from the amplifiers is accepted and counted. For last year's proposal, a contiguous detector volume was used to validate the predicted detector capability from the Monte Carlo simulation and as a baseline in determining the improved peak to background ratio expected from the split-stack configuration. We developed a split stack of four detectors. The effect of the split was optimal with 1 and 3 detectors, the single detector being closest to the gamma source. Coincidence between the two halves of the split stack consists of requiring that as a photon enters the stack, some of its energy must be deposited in each half of the stack. This technique rejects those events of partial absorption preferentially over those events of complete absorption. In figure 2 we see the comparison between Monte Carlo predictions and the experimental setup. The full energy peak to Compton

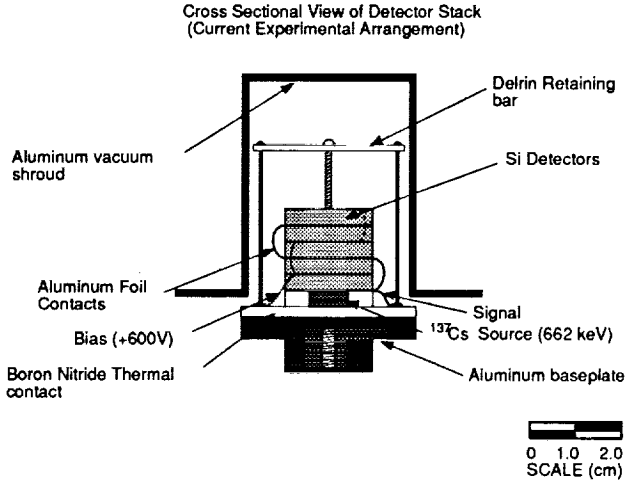

Figure 1. Experimental split-stack detector configuration.

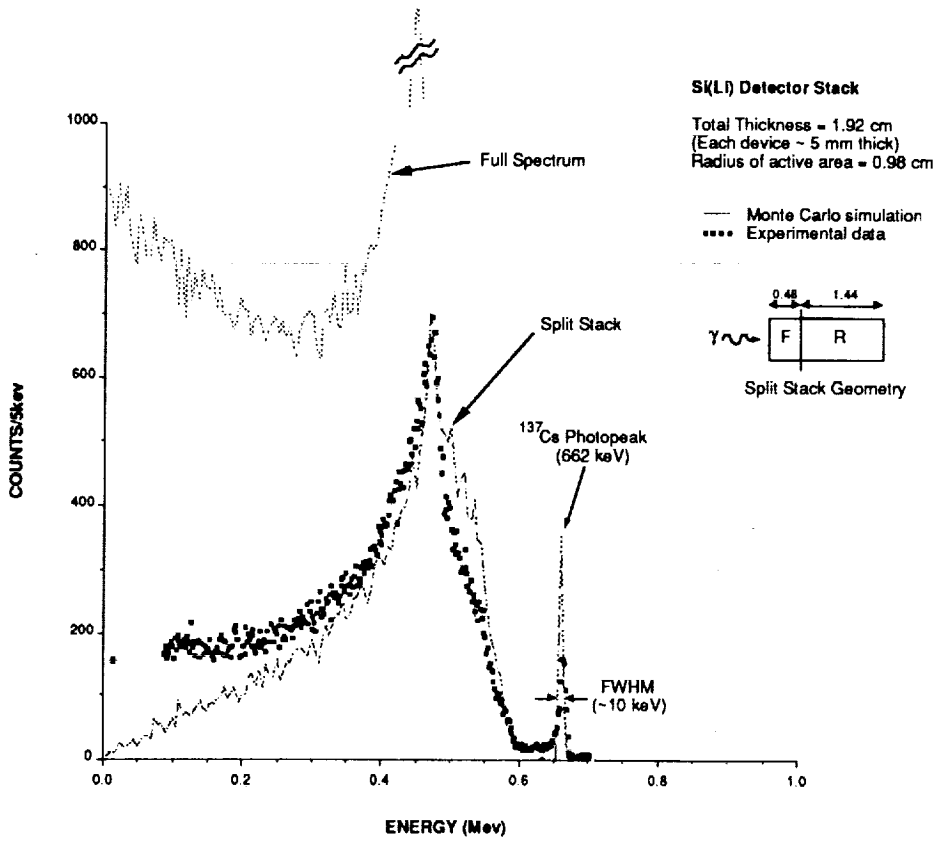

Figure 2. Comparison of experimental and Monte Carlo simulation for split-stack configuration.

background was improved in the lab by a factor of 6; correlating well with the Monte Carlo simulations. The key features of the data also compare well with the computer prediction. The model predicts a better full energy peak because it does not include the effects of noise from various sources. Other improvements were observed by requiring that the minimum energy deposited in each half of the stack be above some threshold. As a result, a further improvement of the peak to background was achieved by employing lower level energy discrimination to both the halves of the split stack, where counts are rejected below 100 keV in either section of the split stack. This improvement is shown in figure 3.

An experimental run was also conducted using two sources having three energies. These sources were Cs^{137} (662 keV) with Na^{22} (551 keV and 1.275 MeV). The experimental results were quite encouraging. Although the summed data showed the three Compton edges, the full energy peaks were difficult to observe. When coincidence was used, the full energy peaks were comparable with the Compton edges and the high energy peak at 1.275 MeV was visible. Also the Compton edges which varied in height significantly in the sum spectrum were brought within the same order of magnitude in the coincidence spectrum. The results are shown in figure 4.

A second cryostat has been developed for variable temperature work. The second baseplate had a smaller radius and was thicker to house a heating element. The retaining mechanism is identical. Lawrence Berkeley Laboratory has started work on temperature characterization of detector devices. They have measured leakage current variation in temperature for a number of devices. The results show a steady drop in leakage current with temperature to a lower instrumentation limit of a few tenths of picoamps.

Publications resulting from study

Paper accepted for presentation at the next Nuclear Science Society Symposium, November 4-9, 1991.

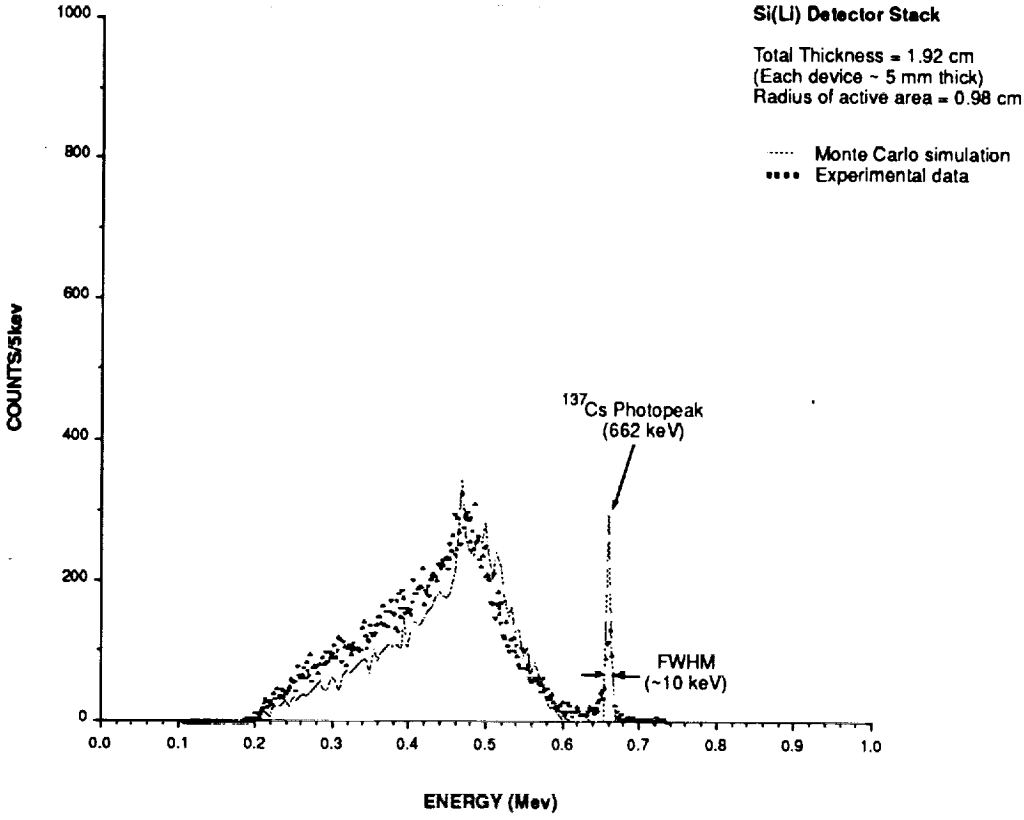

Figure 3. Comparison of experimental and Monte Carol simulation for split-stack configuration with 100 keV energy discrimination.

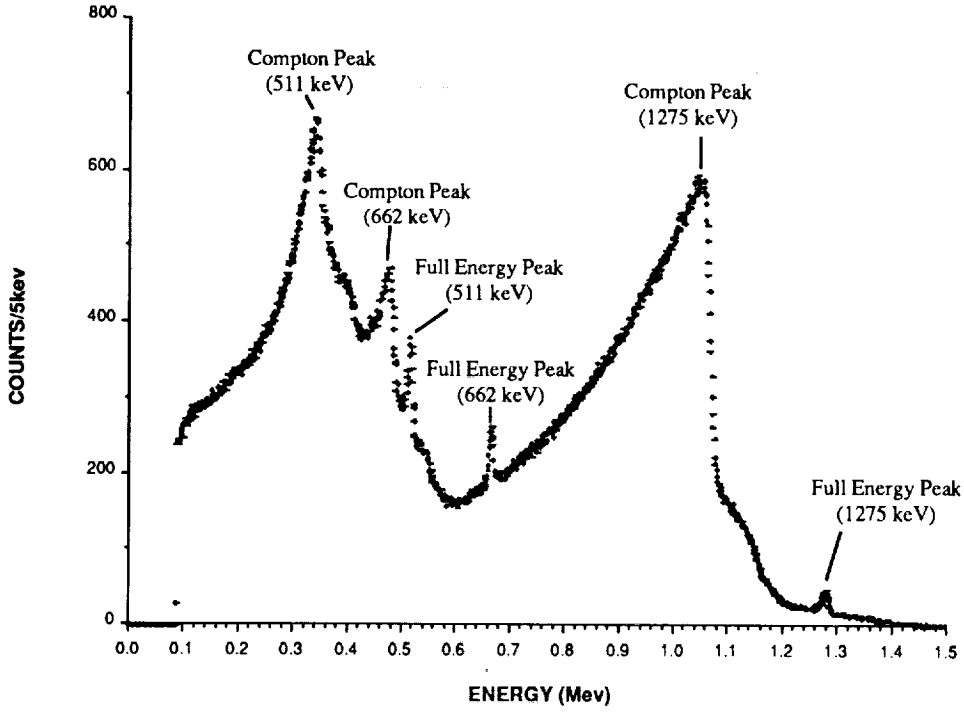

Figure 4. Experimental results for a multiple energy gamma ray source.

Controlling the Lifetime and Reaction Dynamics of High Energy Density Materials (HEDM) by Modifying the Chemical Environment

Investigator(s)
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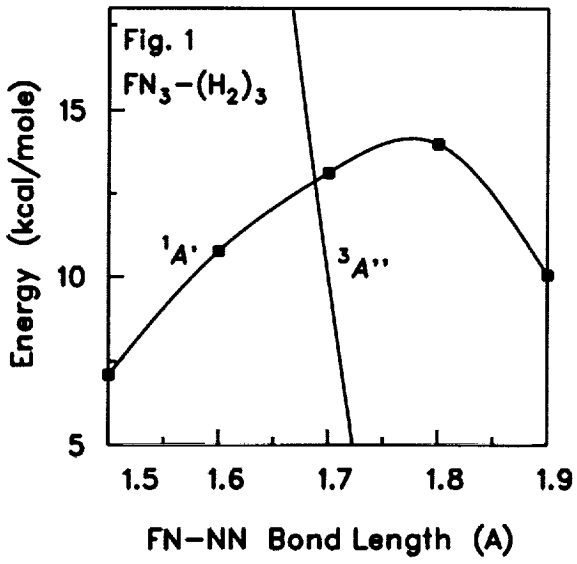
This project investigates how the chemical environment can be modified to stabilize potential HEDM candidates so their energy may be harvested for propulsion. Fluorine azide (FN_3) is used as a prototype molecule to illustrate the general principle.

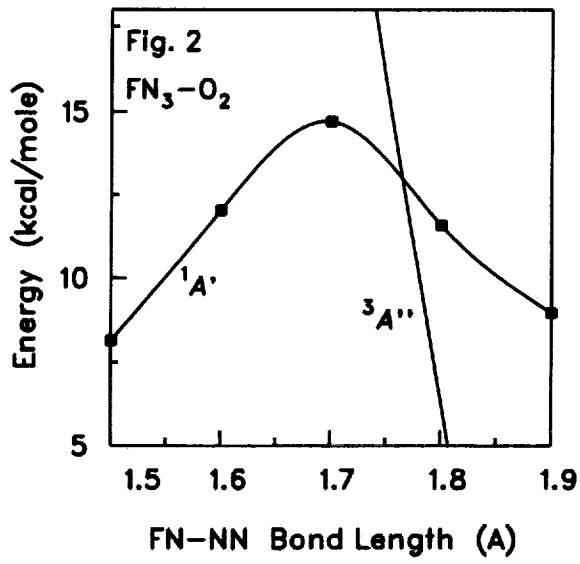
The energy content of FN_3 is higher than that of its dissociation products, N_2 + NF. Thus it decomposes spontaneously except for the existence of an energy barrier to dissociation. The stability of this molecule is directly related to where the potential energy surface of the ground state ($^1A'$) crosses that of the lowest excited state ($^3A''$). If the crossing occurs after the dissociation barrier, then the molecule is relatively stable. By contrast, if the crossing occurs before the dissociation barrier, the molecule may decompose via the highly repulsive $^3A''$ surface, and the rapid dissociation generates a detonation wave. The latter mechanism is the source of the explosive nature of FN_3 in the condensed phase.

The present study makes use of this surface crossing property in FN_3 dissociation. The clusters FN_3–$(H_2)_3$ and FN_3–O_2 are examined using the CASSCF method to determine the dissociation pathways of FN_3 in the presence of H_2 and O_2. Figure 1 shows that FN_3 should dissociate very rapidly in the presence of H_2 because its ground state potential surface crosses the excited state surface before the dissociation barrier. Thus FN_3 is unstable if it is stored in liquid H_2. On the other hand, figure 2 shows that FN_3 in the presence of O_2 should remain relatively stable because the two surfaces cross outside the barrier.

This study demonstrates that materials may be produced which have high energy densities as well as stability. More specifically, the present results indicate that it is possible to store FN_3 in liquid O_2 and generate a highly energetic but relatively stable oxidizer.

The results of this study were presented at the workshop "Performance Enhancement for Hypervelocity Airbreathing Propulsion," July 29–31, 1991, at NASA Langley Research Center.





Team Performance Analysis of Information Flow: Human-Centered Approach to Studying Aerospace Groups

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Objectives of the study

Research Objectives: (1) Develop team performance measures and methods for tracking information flow in Level IV payload processing, and (2) identify group communication patterns (both verbal and written) that facilitate effective information flow. Such patterns occur both within and between payload processing teams and will focus on the way in which written documentation supports the information management associated with the task.

Applied Objectives: (1) Identify positive aspects of payload team interaction patterns; develop strategies and recommendations which maintain or promote effective team interface and information management, (2) recommend advanced technology concepts/aids for facilitating effective information flow, and (3) assess how results and methodology can be transferred and generalized to other shuttle operations and to aircraft maintenance operations.

Progress and results

Our technical approach was a three-phase case study in which Phase I consisted of field observations and interviews for defining the research focus and development of methodology. We conducted this preliminary data gathering within the Level IV Payload Processing Operations Division and observed the ongoing tests associated with STS 40/SLS mission. Because we were attempting to design a study with both scientific and applied objectives, this preliminary information gathering phase was both time consuming and complicated. Data gathering as well as data analysis are more problematic in fully operational settings because the research cannot intrude upon or disrupt actual operations in any way (see Lincoln and Guba, 1985; Cook and Campbell, 1979). On the other hand, we selected the Level IV Payload Operations as a case study because it represented the result of a highly successful management decision; namely to utilize civil service engineers to accomplish this work with hands-on support from contractor technicians. This approach was highly successful in terms of new engineer development, team building, and consistently high quality technical work.

Phase II focuses on the analysis of communication interface within and between operations teams and the way in which written documentation supports the information management. We chose to focus on Mission Sequence Tests (MST) both at Level IV and Level III/II, beginning with STS 42/IML. Currently, we have procedures, documents and audiotapes for IML Level IV MST and will be acquiring IML Level III/II MST as well as observations from STS45/ATLAS MST.

ARC researchers are focusing on describing and assessing "standard" procedures for managing information by comparing "scripted" (procedure derived) and actual communications that take place during MST. We have developed a coding system for characterizing the procedures as well as the way in which procedures are actually carried out during the test. For example, some of the codes that describe scripted commands and responses are as follows:

Commands	Responses
Perform operation X	Operation complete
Verify X	X verified
Quality operation X	Quality operation complete
Status X	Status is ___

Much of the communication that takes place during MST is unscripted, however, and often represents trouble shooting processes, aspects of task management, and strategies for handling deviation and delays. Non-scripted codes include numerous categories of question-answer sequences as well as unsolicited task clarifications and suggestions. Much of the coding methodology is based upon work conducted at ARC in studying crew communication and coordination on the flightdeck (see Foushee and Manos, 1981; Kanki and Foushee, 1989).

Every trouble shooting process, by its very nature, can expect to confront a variety of problems, from inoperative equipment to unexpected delays and unavailable resources, to simple misunderstandings of the task at hand. Our communication analysis will focus on how the team members handle deviations from procedure, both formally and informally. We expect to identify and characterize successful coping strategies for resolving a variety of online anomalies.

UCF researchers are focusing on the development of recommendations and technology aids for promoting effective team interface and information flow. Specifically, this part of the project has been analyzing the paper communication related to the MST including pre-TAP (Test and Assembly Procedures) documents and deviations. The format of the TAP document was reviewed based on observations during the MSTs and successful team strategies. A series of laboratory tests focusing on specific format recommendations for enhancing readability, legibility, and navigation qualities of the TAP is being designed.

Finally, a software-based information support system was conceptualized using sample prototyping methods. Progress to date on this system is the identification of desirable supporting functions, and a series of screens which simulate these functions. The system would allow personnel to access current changes and status of MST, including deviations, quality activity, and overall progress of the time slice. Currently, feedback from the operational community is being enlisted.

Phase III will consist of integrating the results determined in both the ARC and UCF portions of the Phase II work. In addition, a significant objective of this final phase of the case study is to determine the generalizability of results and methodology to other aerospace domains. Specifically, we are interested in (a) other aspects of shuttle processing, such as those performed in the Orbiter Processing Facility, and (b) aircraft maintenance facilities, such as those performed by commercial transport companies, military transport, and aircraft manufacturers.

Significance of the results

Although the project is ongoing, we expect the results to accomplish several goals. From a methodological perspective, we expect to develop a means for evaluating team performance and tracking information flow which is generalizable to other aerospace domains.

Specific to the Level IV Payload Operations domain, we expect the following research products: (a) recommendations regarding successful team coping strategies for resolving online anomalies and deviations and promoting effective team interface and information management, (b) recommendations for procedure design changes within the organizational and documentation guidelines, and (c) development of a prototype information support system in which both static and dynamic information regarding persons, operations, and facilities are more accessible.

Publications resulting from study

W. Rock (Manager of the Technology and Advanced Projects Office, KSC) briefed the project to the Aerospace Safety Advisory Panel, Kennedy Space Center, FL, Oct. 1990.

Invited presentation entitled "Maintenance Team Performance and Information Flow in Shuttle Processing Operations" at the AIAA/NASA/FAA/HFS Conference, Challenges in Aviation Human Factors: The National Plan, Vienna, VA, Jan. 1991.

Workshop conducted for the Crew Factors group and other researchers working in the KSC operational environment, July, 1991. Projects discussed included:

1. Modeling the NASA Test Director/ Remington, Kessel, ARC
2. Information Flow and Team Performance during Mission Sequence Test (MST): Communication Analyses/Kanki, Elsback, Veinott, Irwin, ARC
3. Information Flow and Team Performance during Mission Sequence Test (MST): MST Procedure Aids/Danz, Univ. Central Florida
4. Multi-Cultural Work Groups at KSC/Reyes, UC Santa Barbara
5. Astronaut Science Advisor: Human Factors Lessons Learned/Statler/ARC

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Development of Experimental Techniques for Thermoelastic Vibration Testing

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H. Todd Snyder, PRC Systems Service

Objectives of the study

The overall objective of this research was to develop experimental techniques to conduct vibration testing on structures subjected to high temperatures. Specific objectives include developing test specimen mounting fixtures that would not affect structural and thermal boundary conditions, determining optimal high temperature instrumentation devices, and conducting high temperature tests on simple structures to create an experimental data base for analysis verification.

Progress and results

Experiments have been designed at the Ames Dryden Flight Research Facility to measure the modal characteristics of structures at elevated temperatures. Initial test articles consisted of simple, flat plates and panels but will eventually progress in complexity as the effects of heat on the modal characteristics are better understood. Structures that have been tested to data and the maximum temperature at which modal data was acquired are shown in table 1.

A schematic of the heater control, thermocouple data acquisition equipment, and the accelerometer data acquisition equipment are shown in figure 1. Thermal control of the oven, which is used to heat the test articles, is accomplished with a digital, adaptive, closed-loop system. The power control computer receives feedback temperature information from the thermocouples located on the test article. The power output levels for the rectifier power controllers that provide energy to illuminate the quartz heating lamps in the oven are continually adjusted to maintain

Table 1. Test article and the maximum temperature at which mode data was acquired

Test article	Maximum temperature
Flat aluminum plate	700°F
Flat composite plate	375°F
Built-up aluminum structure	800°F
Rene'41,titanium honeycomb panel	1400°F

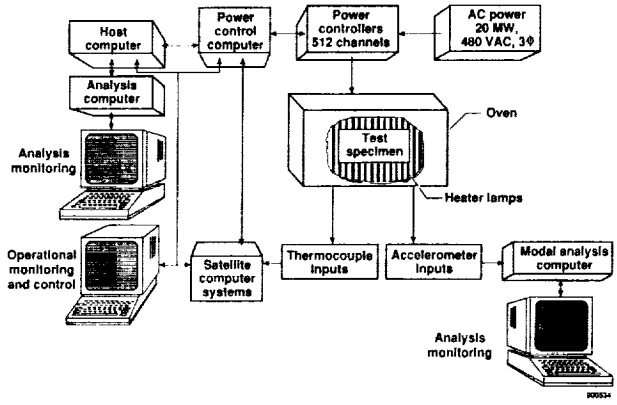

Figure 1. Experimental equipment.

precise temperature control in the oven. The satellite computer also acquires the thermocouple data for display and storage. The modal analysis computer system acquires the accelerometer data for display, analysis, and storage.

An enclosed oven is used to heat the test article to the desired temperature profile. The oven is divided into three heating zones. Uniform heating can be accomplished by heating all zones to the same temperature; nonuniform heating can be accomplished with each zone at a different temperature; and transient heating is accomplished by heating an end zone at a specified heating rate. The current oven is designed for a maximum temperature of 1500° F and a maximum heating rate of 7° F per second.

Each test article is suspended in the oven by a combination of elastic bungee chord and steel cable. The portion of the suspension system that was inside the oven was made of steel to withstand the heat. The length of the steel cable was made as short as possible to avoid affecting the plate's modal characteristics.

The test articles are excited by means of an instrumented impact hammer. Impact excitation was provided to the structure under test by striking a rod which is attached to the plate and protruded through an opening in the oven. This type of excitation provided a way to excite the test article in the shortest amount of time which was essential during transient heating. A typical test with one oven heating zone firing is shown in figure 2.

The test article vibration response to excitation is typically measured by accelerometers. These devices are not normally designed to function in environments

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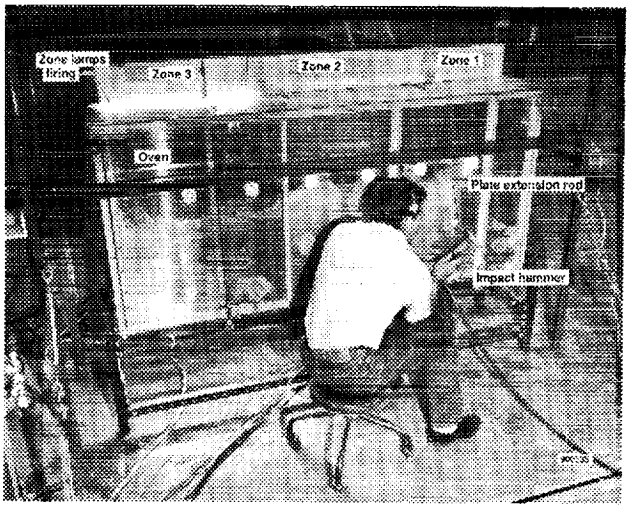

Figure 2. Enclosed oven heating an aluminum plate.

of extremely high temperatures. The accelerometers that can withstand high temperatures are generally very heavy with respect to the weight of the article being tested and therefore have a large effect on the modal characteristics of the structure. Typical light weight accelerometers, such as the devices used for the current series of tests, are generally rated to a maximum temperature of approximately 550° F. For temperatures above 550° F, other types of measurement devices are required.

Laser vibrometers have been successfully used to measure the vibratory response of test articles heated to 1400°F. Figure 3 show the use of the laser vibrometer during a typical test. A laser vibrometer measures the doppler shift of the beam of light reflected from the test article to determine the velocity of the vibration.

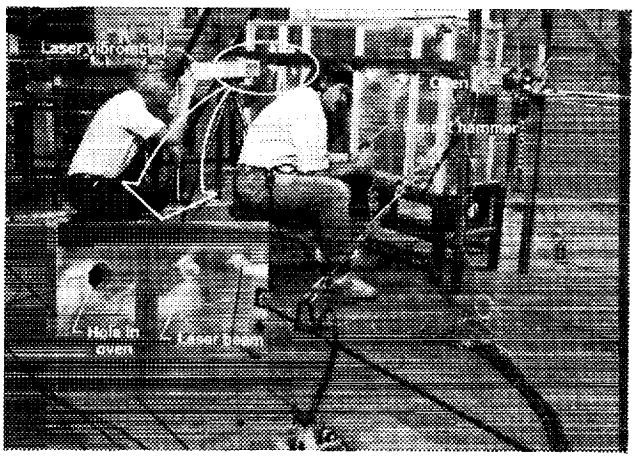

Figure 3. Thermoelastic vibration testing with a laser vibrometer.

This device can be used to a much higher temperature since it is a nonintrusive device. One disadvantage of using a laser vibrometer is that the ones currently available on the commercial market are single pixel devices. This restricts current testing to uniform heating since the vibrometer must be moved from test point to test point to acquire the vibratory response data. Response data that must be acquired simultaneously for all test points on the entire test structure, such as for nonuniform and transient heating tests, cannot be accomplished with the laser vibrometers that are currently available. Research and development of a multi-pixel laser vibrometer is ongoing. It is likely that such a device will be available for hot structures vibration testing in 1992.

Analytical predictions of frequencies and mode shapes of the test articles tested to date have been performed. A comparison of experimental and analytical data is shown in figure 4. This comparison provides some insight into the need of providing an experimental data base for comparison with analytical predictions. The analytical predictions shown in the figure were preliminary calculations and show that some discrepancy between the two sets of data exists at the higher temperatures. The data indicate that as the temperature of the structure increased, the modal frequency decreased. The preliminary predictions obtained from the analysis indicate more of a decrease in frequency at the higher temperature than what was actually measured. Each analysis used finite-element modeling to determine the change in vibration frequency caused by various temperature profiles. The analyses not only modeled the change in modulus of elasticity caused by the increased temperature but also

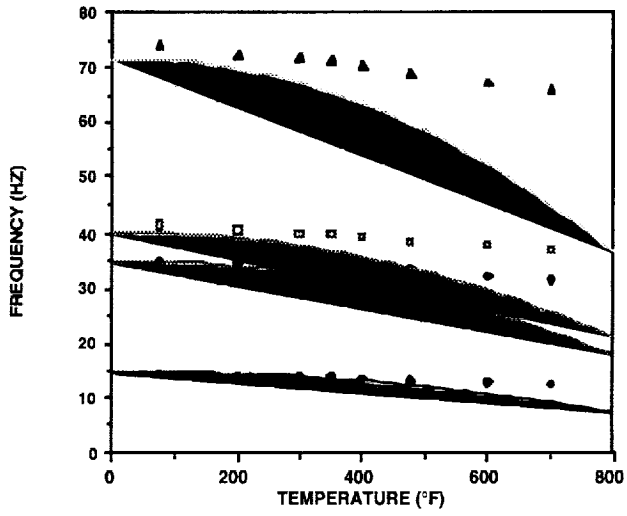

Figure 4. Predicted and experimental data comparison.

the thermal stresses caused by the large temperature gradients. Additional experimental data acquired to date have indicated that the damping of flat plates and panels increases as the temperature increases and that the mode shapes do not vary with temperature.

Significance of the results

The application of this experimental data base can be used to validate and develop confidence in the analytical procedures used to determine the characteristics and structural integrity of a structure at elevated temperatures.

Publications

1. Thermoelastic Vibration Testing. NASA TM-101742, Apr. 1991.
2. Determination of Effects of Heating on Modal Characteristics of an Aluminum Plate With Application to Hypersonic Vehicles. NASA TM-4274, Apr. 1991.
3. High Temperature Ground Vibration Test Techniques, Soc. for Experimental Mechanics Conference, Bethel Conn., Nov. 1991.

Application of Video Imaging for Data Acquisition and Processing of Rotorcraft Flow Visualization

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The objective of this study is to implement an imaging system capable of supporting various flow visualization methodologies (such as the wide-field shadowgraphy technique and smoke flow visualization) for real-time data acquisition and storage of high resolution flow field structures. This research will have a Center-wide impact by making new and innovative imaging technology available for (1) basic fluid dynamics research on vortex instabilities and breakdown studies and (2) applied research to aeronautical components or vehicles.

A specially configured video imaging system was designed inhouse and contracted out to Uniforce Sales and Engineering. The system was delivered Sep. 26, 1991, and includes the following:

1. a computer control unit to send a trigger to the strobes and cameras
2. two high resolution asynchronous video cameras
3. two frame grabber boards and software written to drive the boards
4. a computer platform for housing the boards and processing digitized images.

The system is installed in the 40- by 80-Foot Wind Tunnel. It is currently being checked out to verify asynchronous image capture for various rpm conditions. Full frame image acquisition and high resolution image quality are also being examined. Modifications will be made to the image processing software in order to automate data reduction of the simultaneously acquired image pairs. Image pairs will be used to resolve accurate three-dimensional rotor wake measurements.

Once the system is completely checked out, it will be readied for shadowgraph and smoke flow visualization testing to examine the detailed wake structure for the following upcoming tests in the National Full-Scale Aerodynamics Complex: 1) the 7/38-scale V-22 rotor system, 2) full-scale S-76 rotor system, and 3) small-scale Blade Vortex Interaction test.

Stanford University-NASA Ames Research Center Global Change Institute

Investigator(s)
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W. Gary Ernst, Stanford University

Objectives of the study

The graduate research program in global change, a parallel development to the new undergraduate program in Earth System Science, has been organized jointly by Ames Research Center and Stanford University (School of Earth Sciences and the Office of the Dean for Research).

This program will be expanded to include personnel from other NASA laboratories and Bay Area scientific and technical institutions, such as the Monterey Bay Aquarium Research Institute, Carnegie Institution for Biological Research, Electric Power Research Institute, SRI International, U.S. Geological Survey, and the Lawrence Livermore National Laboratory.

Significance of the results

A world-class research program on global change will be made possible with relatively small increases in cost through this synergism.

Progress and results

The effort began in the spring of 1991 with a series of lectures by scientists and engineers from both Ames and Stanford. The research projects started that summer.

The initial research projects supported by Ames and Stanford are:

- *Surface Coatings, Varnishes, and Sub-soil Structures in Deserts as Indicators of Global Climate Change*
  Donald Windeler, PhD candidate in Remote Sensing
  R. J. P. Lyon, Professor of Applied Earth Science
  David L. Peterson, Ecosystem Science and Technology, Ames

- *Ecosystem Controls over Biogenic Hydrocarbon Emission*
  Manuel T. Lerdau, PhD candidate in Biological Sciences
  Peter M. Vitousek, Professor of Biological Sciences
  Harold A. Mooney, Professor of Biological Sciences
  Pamela Matson, Ecosystem Science and Technology, Ames
  Hanwant Singh, Atmospheric Chemistry and Dynamics, Ames

- *Prototype Development for an Ultrasensitive OH Detector*
  Michael DiRosa, PhD candidate in Mechanical Engineering
  Ronald K. Hanson, Professor of Mechanical Engineering
  Charles Chackerian, Atmospheric Physics Research, Ames
  James Podolske, Atmospheric Chemistry and Dynamics, Ames

- *Remote Estimation of Vegetation Biomass using AIRSAR*
  Mark L. Imhoff, PhD candidate in Biological Sciences
  Harold A. Mooney, Professor of Biological Sciences
  Peter M. Vitousek, Professor of Biological Sciences
  Pamela Matson, Ecosystem Science and Technology, Ames

- *Numerical Flow Simulation Study for In-flight Atmospheric Sampling Measurements*
  Erik Monsen, PhD candidate, Aeronautics and Astronautics
  Robert W. MacCormack, Professor of Aero and Astronautical Engineering
  Mark A. Kritz, Atmospheric Chemistry and Dynamics, Ames
  Rudolf F. Pueschel, Atmospheric Physics research, Ames

- *Molecular and Isotopic Characteristics of Oceanic Carbon: Implications for Global Variability of Atmospheric and Ocean CO_2*
  Margaret J. Bac, PhD candidate in Geology
  James C. Ingle, Professor of Geology
  David J. DesMarais, Stable Isotope Biogeochemistry, Ames
  Gregory H. Rau, Stable Isotope Biogeochemistry, Ames

- *Influence of Temperature on Soil Carbon Pools*
  Alan R. Townsend, PhD candidate in Biological Sciences
  Peter M. Vitousek, Professor of Biological Sciences

David J. DesMarais, Planetary Biology, Ames
Chris Potter, Ecosystem Science and Technology, Ames
Pamela Matson, Ecosystem Science and Technology, Ames

The 1991-92 Stanford-NASA Ames Global Change/Earth System Science Seminar Series began this fall. Ames is hosting the following seminars featuring speakers from Stanford:

October 11: Jonathan Roughgarden, Departments of Biological Sciences and Geophysics, Stanford University. "Mesoscale Oceanographic Feature Control Ecosystems of the Intertidal Zone."

October 25: Peter M. Vitousek, Department of Biological Sciences, Stanford University. "Global Changes and the Nitrogen Cycle."

November 8: Chris Field, Carnegie Institution. "Global Carbon Balance from a Single Leaf Perspective."

November 22: Peter Brewer, Monterey Bay Aquarium Research Institute. "The Oceans in the Global Carbon Cycle."

December 13: John Weyant, Energy Modeling Forum, School of Engineering, Stanford University. Topic to be announced.

In addition, the first graduate Student Research Forums will be held at Stanford, November 1 and 15, 1991, where results to-date will be presented and discussed.

Surface Temperature Field Mapping by Luminescence Imaging

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Other personnel involved
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and J. B. Callis,
University of Washington

Objectives of the study

Assess the feasibility of developing a temperature sensitive luminescent coating that is compatible with the previously developed pressure sensitive luminescent coating. The ultimate goal being the development of a luminescent coating capable of simultaneous surface pressure and temperature field measurement.

Progress and results

A molecule has been identified that is both a suitable temperature sensor and compatible with the current pressure sensitive paint matrix. The temperature response characteristics of this material are being identified through static calibration tests.

The use of the temperature sensitive coating alone for heat transfer studies is being evaluated through static (heated body) and wind tunnel tests. In these tests temperature measurements using conventional sensors are simultaneously being made for comparison to the luminescent paint data. The methodology and apparatus for making field measurements of tem-perature over a surface have been developed. Quantitative temperature measurement using the luminescent temperature paint has been demonstrated.

The first step in incorporating the temperature sensitive material into the pressure sensitive paint, producing one coating providing simultaneous pressure and temperature field measurement, has been taken. Static calibration of this dual pressure/ temperature formulation to define its characteristics is under way. From these calibration tests, the formulation is being adjusted to maximize the dynamic range of each individual sensor. Preparations for wind tunnel tests to evaluate the dual sensor coating are under way.

Significance of the results

The paint method outlined here has a number of advantages over current conventional temperature measurement methods. The foremost advantage is that it provides a measurement of the continuous temperature field over a surface, unlike conventional methods which provide information at discrete points only. A major benefit is that it reduces wind tunnel model cost since it avoids the installation of conventional temperature sensors. The paint method also displays cost advantages when compared to infrared imaging methods, being far cheaper to construct and implement. The reversible and reuseable nature of the paint is also a beneficial aspect that must not be overlooked. The development of the dual pressure/temperature paint will bring a unique capability to aerodynamic testing by providing a means of mapping the thermodynamic environment over an aerodynamic surface.

The Laser Digitizer Project

Investigator(s)
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Introduction

The field of Computational Fluid Dynamics (CFD) is dedicated to computing performance characteristics of an aircraft, solely from its shape. Specifying the shape precisely is the hard part. By some accounts, the surface definition step takes 70% of the man hours expended in CFD. This project strives to reduce the surface definition time, in some cases by more than an order of magnitude.

Many aircraft are designed by computer; their shapes are already available in machine readable form. When this is not the case (for example, when a wind tunnel model has been modified) some way must be found to specify the shape in a machine readable form. One way is to use a 3D digitizer.

This device can provide coordinates of surface points at rates exceeding 14,500 per second. Thus it is possible to digitize an entire model in a few minutes. The accuracy of measurement on a flat white surface is advertised at 0.005 inches. This corresponds to less than 1/8 inch on a full scale aircraft.

Although the digitizer provides measured points rapidly, it does not produce a surface. At a minimum, a triangular faceted polyhedral approximation to the aircraft shape is required. With the point densities made possible by the digitizer, this approximation can be quite good. What is missing is connectivity information; which points are connected to which. This information can be recovered using either of two algorithms implemented under the project.

Description of laser digitizer

Laser digitizers perform the same function as a coordinate measuring machine but use optics instead of a mechanical probe. Given two coordinates (say x and y) they measure the third (z). The lack of physical contact permits measurement of soft surfaces (such as people) and avoids measurement errors due to friction between the probe and the model.

The greatly reduced mechanical inertia of the laser digitizer results in much higher sampling rates. A typical scan requires a few seconds and produces 128,000 data points. For reference, a theodolite survey of a full scale aircraft at Ames required several days to produce about 12,000 data points.

The optics consist of a laser beam and one or more CCDs (eyes). Conceptually the laser illuminates the model and a laser spot on the model is seen by at least one of the eyes (see fig. 1). The intersection of the line of sight and the laser beam establishes the coordinates of a point on the model surface. In one model, the laser beam is moved very quickly along one axis by means of a mirror. Our digitizer is slightly different in that the moving mirror is replaced by a laser sheet which is detected by arrays of CCDs.

Illumination of different parts of the model is accomplished by means of a traversal mechanism. This is a large, solidly built, machinist's table which holds the model (see fig. 2).

Algorithms for triangulating surfaces

The laser digitizer provides a large number of surface measurements from several different viewpoints. The task at hand is to construct a topologically correct surface that incorporates all the measured data, the so-called surface reconstruction problem. In this initial effort, surfaces are represented as triangular faceted polyhedra.

Two methods are described here. Both make use of Delaunay triangulation, either in 2D or 3D. The 3D Delaunay triangulation has been ported to the 128 processor iPSC/860 parallel supercomputer as part of this project. Speeds equivalent to a Cray Y-MP processor have been obtained so far. This work is still in progress, and further speed-ups of an order of magnitude are anticipated.

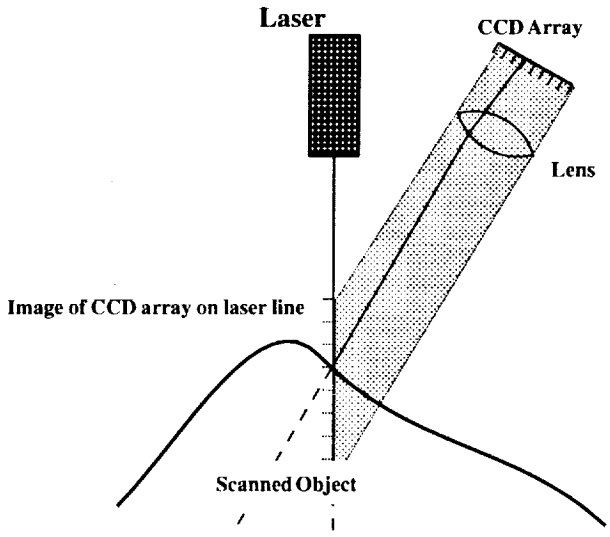

Figure 1. Optical setup for a laser digitizer.

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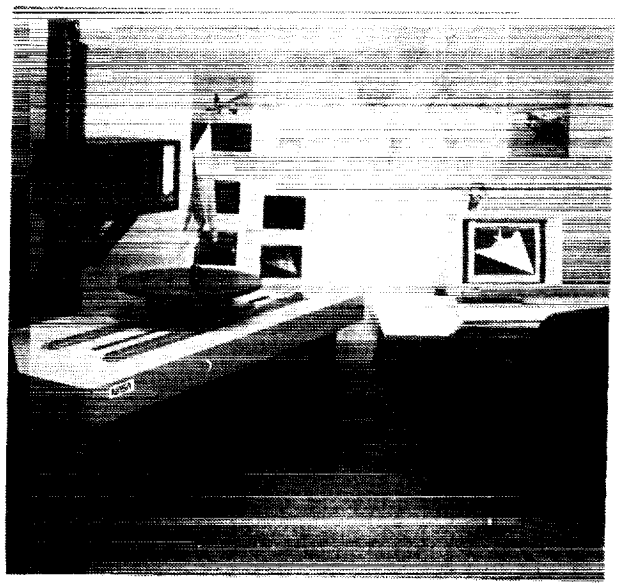

Figure 2. Photograph of Cyberware Laser Digitizer and Iris Workstation.

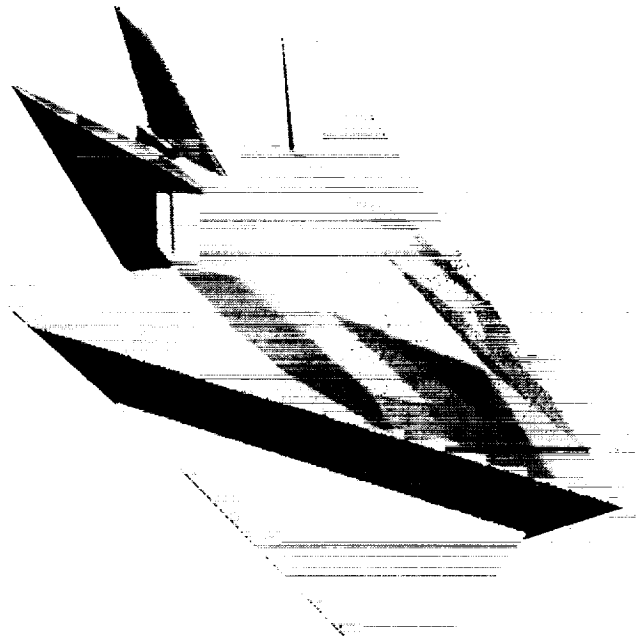

Figure 3. Rendering of an F-117A planform from an unstructured carpet plot (280,000 points).

Carpet plotting

Perhaps the easiest and quickest way to obtain a three-dimensional triangulation is to use a carpet plot (sometimes called a range map). This is the traditional way of plotting a function of two variables. In this case the distance from the scanner to the model (the range) is platted as a function of the other two coordinates.

This approach is less straightforward when the measurements are not taken on a Cartesian grid. As before, the range (z) can be plotted as a function of the other two coordinates (x and y). This leaves the problem of providing a two-dimensional connectivity between points to replace the implied connectivity of a Cartesian grid. Delaunay triangulation is used here.

Delaunay triangulation of scattered data in two dimensions is a classical problem. Such a triangulation can be carried out efficiently and robustly. Even on a workstation, speeds of 500 points/second have been demonstrated. Once this triangulation is available, carpet plotting is straightforward. In figure 3, an unstructured carpet plot is used to render the planform on an F-117A.

This method is very quick, but its usefulness depends on combining many carpet plots. This, in turn, reduces to a problem in polyhedron intersection.

Pruning the convex hull

Another way to obtain surface triangulation is to begin with a Delaunay tesselation of all the points measured. This leads to a set of tetrahedra which fill all the space up to the convex hull of the points. Usually some of these tetrahedra will lie partially or completely outside of the aircraft and should be deleted (pruned). These tetrahedra can be identified with line-of-sight information available from the scanner; they lie along the path of the laser for a particular surface point. Therefore they must be at least partially outside the aircraft.

After pruning, the remaining surface triangles provide a good representation of the surface. Figure 4 depicts this process in two dimensions. Figure 5 shows the aft end of an F-117A model reconstructed by this process. This technique was originally suggested in the context of computer vision. More recently, it was independently derived as a part of this project.

Algorithms for flow solution

A large number of algorithms have been proposed and demonstrated in two space dimensions for solving the Euler and Navier-Stokes equations on unstructured grids. Several of these algorithms have been extended to three space dimensions using meshes composed of tetrahedral volumes. These algorithms vary in sophistication from Glerkin-like formulations with added artificial dissipation to upwind algorithms utilizing Riemann solver-based flux functions and high order reconstruction.

Current problems and future work

This paper describes work in progress. Nevertheless, it can be said with some certainty that this approach will

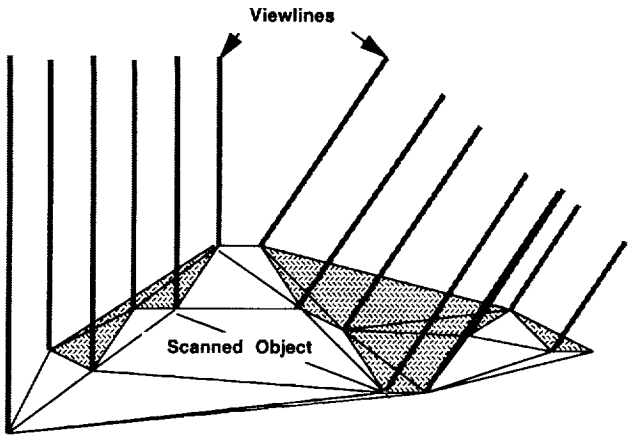

Figure 4. A two-dimensional representation of pruning.

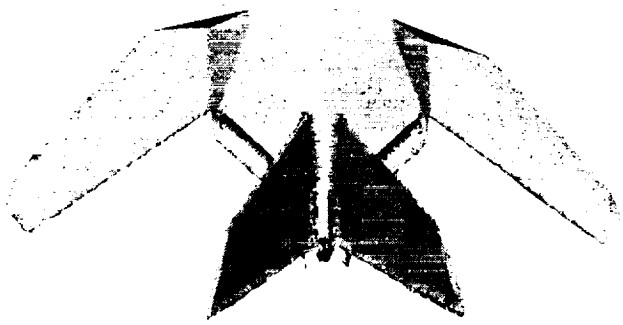

Figure 5. A solid model of an F-117A tail section obtained by pruning.

provide suitable surface definitions if sufficiently accurate data can be obtained from the scanner. Right now, errors of two types are causing problems. First, there is a significant random component to the error. Most of that seems to be due to the laser speckle, a subtle optical effect. This makes the surface appear rough, almost corrugated. Second, there appear to be alignment problems between scans. These are potentially fixable, but currently are around 0.080 inches, a huge error. Work continues on removing such errors.

In the coming year, work will proceed in several areas. First of all, reducing scan errors is a top priority. This will dramatically improve the reconstructed surfaces. Second, the speed of the surface reconstruction process and the flow solvers can be dramatically increased by moving all the software to the iPSC/860, a massively parallel machine. Finally, we have plans to automatically construct surface patches, surface grids, and volume grids (unstructured) using the reconstructed surface as input. Using the existing flow solvers, we will achieve the dream of a fully integrated solution process from model to solution.

The major effect of a large improvement in solution time is to reduce the cost of simulations. This in turn will allow CFD to be used much more widely as a design tool. Today CFD is uneconomic except on the largest projects. If the project doesn't involve hundreds of millions of dollars, CFD probably won't be used. Lowering this threshold by two orders of magnitude admits many more applications. Among the new applications might be low flush toilets, windmills, general aviation, automobile racing, and windloading of large structures.

Publications and acknowledgements

More information can be found in several recent publications resulting from this project. Specifically see: 3D CFD In a Day, the Laser Digitizer Project. Marshal L. Merriam and Timothy J. Barth. AIAA-91-1654, AIAA 22nd Fluid Dynamics, Plasma Dynamics, and Lasers Conference, June 24-26, 1991, Honolulu, Hawaii; and Surface Reconstruction From Scattered Data Through Pruning of Unstructured Grids, Cathy M. Maksymiuk and Marshal L. Merriam. AIAA-91-1584, AIAA 10th Computational Fluid Dynamics Conference, June 24-27, 1991, Honolulu, Hawaii.

The authors would like to acknowledge the work of Catherine Maksymiuk who implemented and continues to improve the pruning algorithm, Kumaran Kalyanasundaram who implemented the polyhedron intersection algorithm, and Amar Gandhi who ported a flow code to the iPSC/860.

Detection of Autotrophic Life on Mars by Surveying for Oxygen

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Ph.D. candidate, Indiana University

Objectives of the study

To conduct experiments leading to instrument definition for detecting autotrophic life on Mars. It is anticipated that the instrument will survey the surface of Mars for a byproduct of carbon fixation, oxygen. This instrument would be of use to exobiology and to human exploration of Mars.

Progress and results

Carbon fixation, which is coupled to the process that produces oxygen in autotrophic organisms, was studied during a diurnal cycle in several microbial mats. The mats studied live in the intertidal in Baja California. One was a cyanobacterial mat composed primarily of *Lyngbya*, the other a mat that occurs several millimeters beneath the sand so is not apparent from the surface. Results of carbon fixation studies can now be expressed in terms of oxygen evolution.

In addition, an oxygen meter has been obtained to conduct experiments to determine if changes in oxygen can be detected from the surface of the mats.

Significance of the results

The results show that significant amounts of carbon fixation occur in these communities. During the second year we will determine how the oxygen evolved during photosynthesis can be measured from the surface.

Publications resulting from study

Lynn J. Rothschild & Lorraine J. Giver. Carbon fixation in a cryptic microbial mat: A source of organic carbon for beach ecosystems. Manuscript in preparation.

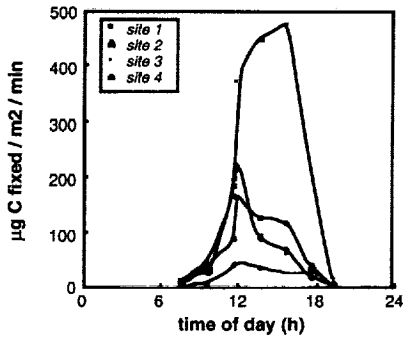

Figure 1. Diurnal pattern of carbon fixation in a "cryptic" intertidal microbial mat. Carbon fixation was determined by assessing incorporation of $^{14}CO_3$- into acid-stable compounds at four different sites.

Neurocomputer Development for Fast Processing of Massively Parallel Recordings from Brain Cells – Developing a "Brain" to Study the Brain!

Investigator(s)
A. J. Pellionisz and D. L. Tomko,
Ames Research Center,
Moffett Field, CA 94035-1000

Progress and results

A prototype neurocomputer has been constructed in the form of a Macintosh IIfx microcomputer, hosting a LEVCO parallel processor board featuring the INMOS Transputer. This system, together with the parallel processing algorithm developed by Pellionisz for analysis of multielectrode data, is presently operational. Basic research aspects of the project were presented in the invited lectures at the International Conference on Artificial Neural Networks in Helsinki (1), in the International Conference on Volume Transmission, in Stockholm (2), and in the International Conference on Head Control in Fontainebleau (4). Based on the developed technique for neurocomputer analysis of electrophysiological data from experimental animals, a collaborative project was established with J.R. Bloedel (Phoenix, AZ). A primary pilot-project was completed to demonstrate the ability of the system to discern functional geometry of neural firings in biological neural networks (3). Application of the technique to vestibulo-oculomotor systems is facilitated by establishing the structural geometry of such systems (7). The impact of the technique of revealing neural geometry from biological (vestibular) systems was presented in invited lectures at two International Conferences: one on vestibular systems, in Palo Alto (5); and one on vestibular control of movement and posture, in Switzerland (6).

Full list of publications during FY 91

1. Pellionisz, A. (1991) Discovery of Neural Geometry by Neurobiology and its Utilization in Neurocomputer Theory and Development. International Conference on Artificial Neural Networks, Helsinki, Finland; T. Kohonen et al., eds.; North Holland, 485-493.
2. Pellionisz, A. (1991) The Geometry of Massively Parallel Neural Interconnectedness in Wired and Wireless Volume Transmission. K. J. Fuxe and L. Agnati, eds., Stockholm, Sweden. Raven Press, New York, 557-568.
3. Pellionisz, A. J. and Bloedel, J. R. (1991) Functional Geometry of Purkinje Cell Population Responses as Revealed by Neurocomputer Analysis of Multi-Unit Recordings. Soc. Neurosci Absts., New Orleans, LA.
4. Pellionisz, A. J. (1991) Multidimensional Geometry Intrinsic to Head Movements around Distributed Centers of Rotation: A Neurocomputing Paradigm. 2nd Symposium on Head Control, Fontainebleau, France; A. Berthoz, W. Graf and P. Vidal, eds.; Oxford University Press, 316-329.
5. Pellionisz, A. and Tomko, D. (1991) Geometrical Aspects of the Vestibulo-Cerebellar Neurocomputer. Palo Alto, CA; B. Cohen, F. Guedry and D. Tomko, eds.; New York Academy, in preparation.
6. Pellionisz, A. J., C. Ramos, D. L. Tomko and J. R. Bloedel (1991) A Geometrical Approach to the Vestibular Control of Movement and Posture. Natural and Artificial Control of Hearing and Balance, Rheinfelden, Switzerland, Elsevier.
7. Macknick, S., A. Pellionisz and D. Tomko (1991) Geometry of the Vestibulo-Oculomotor System of Squirrel Monkey, in preparation.

Biologically Produced Magnetite and Its Relationship to the Banded Iron Formations

Investigator(s)
Deborah Schwartz, Rocco Mancinelli, and Melisa White, SETI Institute,
Ames Research Center,
Moffett Field, CA 94035-1000
Verne Oberbeck, Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study

The objectives of this study are to identify characteristics of biologically produced magnetite and determine if these characteristics are unique to biologically produced magnetite or if they are also typical of magnetite produced abiotically. Additionally, through this study, we will obtain information on the characteristics of magnetite found in the Gunflint Banded Iron Formation and determine the relationship between biologically produced magnetite and the magnetite found in the Gunflint Formation.

Progress and results

To date, we have successfully isolated magnetite from the sole magnetite-producing organism available through the American Type Culture Collection. We have also successfully isolated magnetite from a type of marine magnetotactic bacteria that has never before been isolated. Morphological, crystallographic, geochemical, and thermal analyses of these biologically produced magnetite crystals have begun. A sample of the Gunflint Banded Iron Formation from Ontario, Canada, has been obtained. Morphological, crystallographic, geochemical, and thermal analyses of magnetite grains from the Gunflint have begun.

Significance of results

Only preliminary results have been obtained thus far. These results do not appear to conflict with our hypothesis that biologically produced magnetite may be related to magnetite found in the Banded Iron Formation.

References: None so far

A Nonlinear Dynamical Approach to Numerical Method Development in CFD

Investigator(s)
H. C. Yee, Ames Research Center,
Moffett Field, CA 94035-1000
P. K. Sweby, University of Reading,
Reading, England
A. Lafon, ONERA-CERT, Toulouse, France
A. M. Stuart, University of Bath, Bath, England
D. F. Griffiths, University of Dundee,
Dundee, Scotland

Objectives of the study

The underlying objectives of this research is to lay the foundation for the utilization of the dynamics of numerics in algorithm development for computational fluid dynamics (CFD). The intent is

1. to reveal the logistics, methodology, and usages of nonlinear dynamics for CFD,
2. to complement the commonly used linearized stability theory in CFD,
3. to investigate the possible sources of errors and slow convergence and nonconvergence of steady-state numerical solutions when using the time-dependent approach to the steady states,
4. to guide the construction of appropriate iteration methods, relaxation procedures, or preconditioners for convergence acceleration strategies in numerically solved boundary-value problems of nonlinear partial differential equations (PDEs) (since most of these methods can be viewed as approximations of a time-dependent PDE), and
5. to provide a better judgement and enhance the understanding of flow visualization of numerical data, such as lines of separations and attachment points.

Referring to the last issue, if the governing PDE and/or its discretized counterparts possess higher than three-dimensional (or infinite dimensional) dynamical behavior, the projections of these higher dimensional dynamics onto a 2-D or 3-D topology can lead to misinterpretation of flow types. Referring to the third issue, in many CFD computations, the steady-state equations are PDEs of the mixed type and a time-dependent approach can avoid the complication of dealing with elliptic-parabolic or elliptic-hyperbolic types of PDEs. However, new uncertainty on the accuracy of the numerical solution arises. This uncertainty is due to the fact that a boundary value problem has been transformed into an initial-boundary value problem with unknown initial data.

Approach and relevance

The tool that is utilized for the current analysis belongs to a new multidisciplinary field of study in numerical analysis, sometimes referred to as "The Dynamics of Numerics." Here, the dynamics of numerics means the dynamical behavior of numerical schemes. To study the dynamical behavior of a numerical scheme means to study the local and global asymptotic behavior and bifurcation phenomenon of the nonlinear difference equations resulting from finite discretization of a differential equation (DE), subject to the variation of parameters such as the time step, grid spacing, and numerical dissipation coefficient.

At the present time, this new interdisciplinary topic remains the property of an isolated discipline with all too little effort spent in pointing out an underlying generality that could make it adaptable to diverse fields of applications. Aside from truncation error and machine round-off error, a more fundamental distinction between the continuum and its discretized counterparts for genuinely nonlinear behavior is new behavior in the form of spurious stable and unstable asymptotes (such as spurious steady states, periodic orbits, limit cycles or numerical chaos) that can be created by the numerical method. Another important fact is that the use of linearized analysis as a guide to studying strongly nonlinear PDEs is insufficient and can lead to misleading results.

Linearized stability analysis (with the initial data sufficiently close to the exact solution) usually can supply only part of the nonlinear stability behavior (e.g., before a bifurcation point occurs) since linearized stability is a local phenomenon. Only a bifurcation analysis can elucidate a more complete nonlinear stability behavior. To obtain a global picture of the nonlinear stability of the bifurcation part of the analysis, one has to resort to more sophisticated mathematical tools, such as local and global bifurcation theories.

An overview of the major results

Utilizing the mathematical tools of nonlinear dynamics to analyze model nonlinear problems and problems containing nonlinear source terms, the following phenomena have been observed (refs. 1-11).

1. With the same initial data, time step, grid spacing and spatial discretization, but different time discretizations, the resulting schemes can converge to different stable steady-state numerical solutions (refs. 2-4). Moreover, it is possible that none of these

numerical solutions is a close approximation to the true solution of the continuum since spurious steady-state numerical solutions can occur **below** as well as **above** the linearized stability limit of the scheme. The unique property of the **separate** dependence of solutions on initial data for the individual continuum and its discretized counterparts is important for employing a time-dependent approach to the steady state in strongly nonlinear fluid dynamics problems and problems containing nonlinear source terms.

2. Because spurious stable steady-state numerical solutions can be introduced by the spatial discretizations as well as time discretizations (refs. 3 and 4), the commonly used "residual test" for convergence in the time-dependent approach to the steady state might be misleading. If the scheme happens to produce spurious steady-state numerical solutions (due to spatial discretizations), these spurious solutions would still satisfy the residual and L_2 norm tests in a deceptively smooth manner (refs. 1-5).

3. Spurious limit cycles and spurious higher-dimensional tori can be generated by finite discretizations of nonlinear PDEs containing zero source terms. The existence of stable spurious limit cycles or higher-dimensional tori might be one of the contributing factors in nonconvergence of the time-dependent approach to the steady state.

4. The occurrence of spurious asymptotes is independent of whether the DE possesses a unique steady state, or has additional periodic solutions, and/or exhibits chaotic phenomena. The form of the nonlinear DEs and the type of numerical schemes are the determining factors (refs. 1 and 2).

5. It is not just the occurrence of stable spurious numerical solutions that causes difficulty. These spurious features of the discretizations often occur but can be unstable; i.e., they do not appear as an actual (spurious) solution because one usually cannot obtain an unstable asymptotic solution by mere time integration. However, far from being benign, they can have severe detrimental effects on the basins of attraction of the true solutions for the particular method. This causes slow convergence or possibly even nonconvergence from a given set of initial data even though the data might be physically relevant (refs. 1,9,11).

6. When linearized stability limits are used as a guide for a time step constraint for highly coupled nonlinear system problems, this time step might exceed the actual linearized stability limit of the coupled equations. In particular, when one tries to stretch the maximum limit of the linearized allowable time step for highly coupled nonlinear systems, most likely all of the different types of spurious asymptotes can be achieved in practice depending on the initial conditions. Consequently the occurrence of spurious steady-state solutions beyond the linearized stability limit is not just secondary, but might be as important as the occurrence of spurious steady states below the linearized stability limit. This is compounded in practical situations in which the exact linearized stability limit usually is not computed; but instead, a frozen coefficient procedure at each time step with a fixed grid spacing is used to estimate the true stability limit of the algorithm. Therefore, in practical computations erroneous numerical results can easily be achieved unknowingly.

7. The knowledge gained from the finite-difference method analysis of problems without nonlinear source terms does not carry over to the problems containing nonlinear source terms. This is evident from the results presented in references 1, 3 and 4.

8. The existence of spurious steady-state numerical solutions sometimes can be linked to the numerical phenomenon of incorrect propagation speeds of discontinuities in time-accurate computations (ref. 3).

9. The manner in which the source term is discretized can drastically affect the stability of the steady-state numerical solutions even when the same spatial and time discretizations are used for the convective part of the reaction-convection equation (refs. 3 and 4).

10. Grid refinement or reduction in the time step does not necessarily result in an improved stability and/or accuracy when the dynamical behavior of the scheme and/or initial data are not known (refs. 3 and 4).

Significance of results

Although more theoretical development and extensive numerical experimentation are needed, we believe that these findings could have important implications in the interpretation of numerical results from existing computer codes and widely used CFD algorithms in combustion, reacting flows, and certain turbulence models in compressible Navier-Stokes computations. In spite of the limited knowledge in hand, we believe it is of importance to know the nonlinear dynamical behavior of the various schemes before their actual use for practical applications. Otherwise, it might be very difficult to assess the accuracy (spurious or otherwise) of the solution when the numerical method is the sole source of the understanding of the physical solutions. Even though the understanding of the topic is still at an early stage; nevertheless, we believe nonlinear dynamics plays a vital role in algorithm development in CFD.

References

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2. Yee, H. C.; and Sweby, P. K.: "Dynamical Approach Study of Spurious Steady-State Numerical Solutions for Nonlinear Differential Equations, Part II, The Dynamics of Numerics of Systems of 2 X 2 ODEs and its Connections to Finite Discretizations of PDEs," to appear.
3. Lafon, A.; and Yee, H. C.: "Dynamical Approach Study of Spurious Steady-State Numerical Solutions for Nonlinear Differential Equations, Part III, The Effects of Nonlinear Source Terms and Boundary Conditions in Reaction-Convection Equations," NASA TM-103877, July 1991.
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6. Griffiths, D. F.; Stuart, A. M.; and Yee, H. C.: "Numerical Wave Propagation in Hyperbolic Problems with Nonlinear Source Terms," University of Bath Report, March 1991, also to appear, SIAM J. of Numerical Analysis.
7. Yee, H. C.: "A Nonlinear Dynamical Approach to Algorithm Development in Hypersonic CFD," Proceedings of the 4th International Symposium on Computational Fluid Dynamics, Davis, Calif., Sep. 9-12, 1991.
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9. Yee, H. C.; and Sweby, P. K.: "On Reliability of the Time-Dependent Approach to Obtaining Steady-State Numerical Solutions," Proceedings of the 9th GAMM Conference on Numerical Methods in Fluid Mechanics, Lausanne, Switzerland, Sep. 25-27, 1991.
10. Sweby, P. K..; and Yee, H. C.: "On Spurious Asymptotic Numerical Solutions of 2 X 2 Systems of ODEs," Numerical Analysis Report 7/91, August 1991, University of Reading, England.
11. Griffiths, D. F.; Stuart, A. M.; Sweby, P. K.; and Yee, H. C.: "Stability of Spurious Steady-State Solutions of Runge-Kutta and Related Methods for PDEs," in preparation.

Climatology of the El Chichon Volcanic Cloud in the Stratosphere

Investigator(s)
Richard E. Young, Ames Research Center,
Moffett Field, CA 94035-1000

Other personnel involved
O. B. Toon and J. B. Pollack,
Ames Research Center,
Moffett Field, CA 94035-1000

Objectives of the study

To numerically simulate the behavior of the El Chichon volcanic aerosol cloud in the Earth's stratosphere and compare the results to observed cloud climatology.

Progress and results

During FY 91 several numerical and procedural problems were solved, and stratospheric simulations were begun with the purpose of doing passive tracer studies of the El Chichon volcanic aerosol cloud. These passive tracer simulations will be followed by fully interactive simulations in which the radiative effects of the volcanic aerosols will be accounted for. The passive tracer calculations serve as a base to which comparisons can be made in order to assess the climatological effects of the volcanic aerosol cloud in the stratosphere. In addition, the eruption of Mt. Pinatubo provides another opportunity to model stratospheric processes and the climatic effects of vocanic eruptions. Comparisons will be made between simulations for El Chichon and Mt. Pinatubo in order to understand why the two volcanic clouds behaved differently after the eruptions.

We have now been able to simulate stratospheric wind and temperature fields for the first several months immediately following the eruption of El Chichon. The results appear to be representative of the observed stratospheric winds and temperatures. We are now in the process of conducting transport computations for the El Chichon eruption. Once these are completed, we will do the same for Mt. Pinatubo and then compare the results.

Significance of the results

The tracer studies now being done for the El Chichon and Mt. Pinatubo volcanic aerosol clouds will provide important information on transport processes in the stratosphere and how such processes vary from year to year. Such knowledge can be used in other applications, for example the dispersion of aerosols emitted by High Speed Civilian Transport aircraft.

Publications resulting from study

Based on the successful stratospheric simulations of the months following the volcanic eruption, a proposal for further work has been submitted to the newly formed NASA Volcano Climate Interaction Program.

Papers for presentation at Professional Society Meetings, Seminars, Symposia, Other Important Forums:

A paper describing our results is being readied for presentation at the AGU Chapman Conference on Climate, Volcanism, and Global Change, to be held in March of 1992.

Development of Excrescence Tolerance Criteria for Laminar Flow Wings at Low Subsonic Speeds

Investigator(s)
Fanny Zuniga,
Ames Dryden Flight Research Facility,
Edwards, CA 93523-0273

A laminar flow transition flight experiment was conducted on the PIK20E self-launching sailplane. The objective of this experiment was to investigate the effects of excrescences, such as forward and aft facing steps, on laminar to turbulent boundary layer transition. In addition, the maximum allowable size of the excrescences which does not cause premature transition will be defined in order to extend and evaluate current tolerance criteria for a laminar flow wing at low subsonic speeds.

Sixteen single-element hot-film sensors were used to detect laminar flow over the test section of the wing, refer to figure 1. High-frequency data of 1500 samples/sec for a maximum of 8 hot-film signals were recorded and stored onto an onboard data acquisition computer.

Fifteen flight tests have been completed which include smooth wing and aft facing step configurations. All test points were recorded at steady, level flight conditions. Chord Reynolds numbers ranged from 0.6 to 2.3 million, and true velocities ranged from 59 to 126 knots. Aft facing steps were simulated by using plastic vinyl sheets of incremental sizes until the maximum allowable height of the step was reached without causing premature transition. The steps were tested at three different chord locations of 10.5%, 24.4%, and 42.6% chord.

Figure 2 shows preliminary results from the data analysis completed thus far. Transition location, x/c, is plotted against chord Reynolds number for the three different chord locations in this figure. The results from the smooth flight indicate natural transition occurring at 61% chord at the test section. The results for the aft step configuration at 10.5% chord show transition location moving forward for increasing chord Reynolds number and increasing step height as expected. Similar trends are evident for the results at 24.4% chord and 42.6% chord. The maximum allowable step height for each chord location has not yet been defined as of the writing of this report.

The results of this investigation will provide aircraft manufacturers with manufacturing tolerances for excrescences on laminar flow wings. Definition of excrescence tolerance is most likely as important to aircraft manufacturers as demonstrating that laminar flow control is a feasible and worthwhile concept.

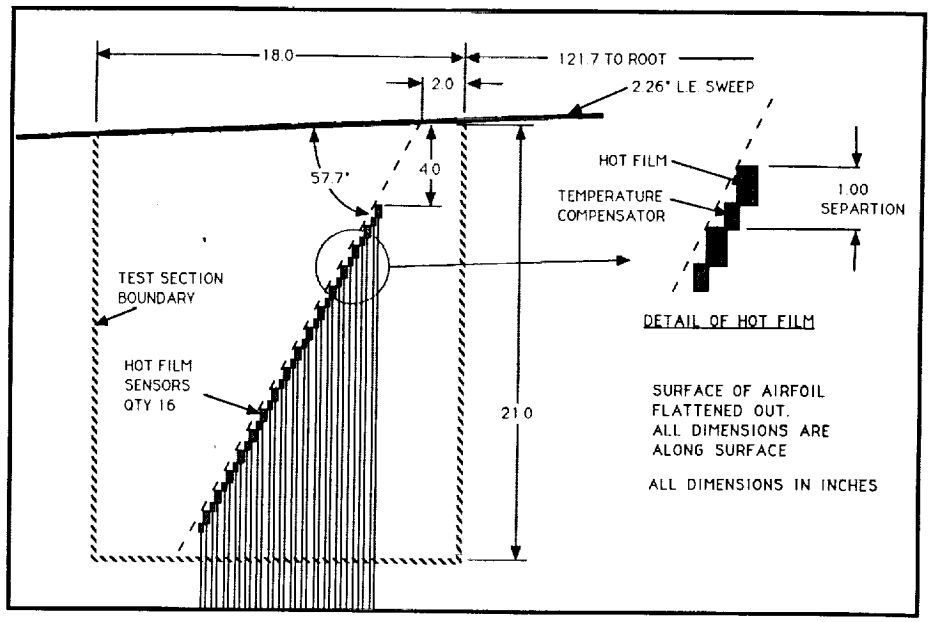

Figure 1. Test section detail.

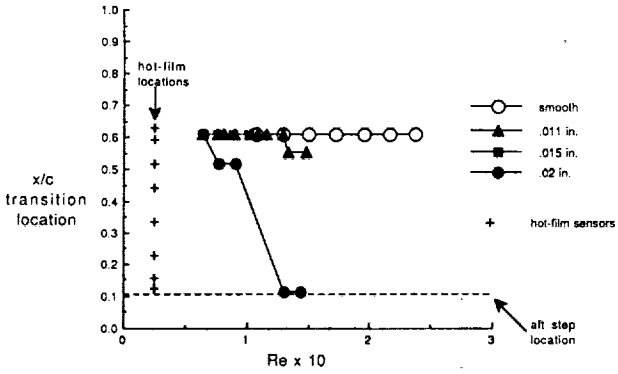

Figure 2(a) Transition location for aft step configuration at 10.5% chord.

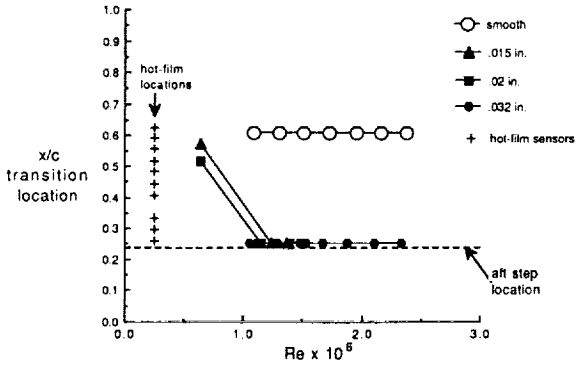

Figure 2(b). Transition location for aft step configuration at 24.4% chord.

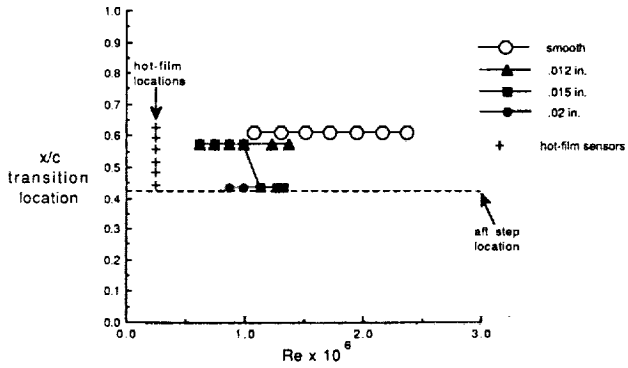

Figure 2(c). Transition location for aft step configuration at 42.6% chord.

At the present time, flight testing is continuing to better define the transition location and to improve the overall quality of the data. Forward facing steps and simulated gap configurations will also be tested. Future plans consist of attaining flow-visualization data to supplement the hot-film data and using multi-element sensors to better define transition location.

APPENDIX

For each of 40 projects sponsored in FY 1991, a brief description and the financial distribution and status follow. Included are the status reports on five projects that began at the end of the fiscal year and have no narrative reports. The reports are arranged alphabetically by the last name of the first investigator.

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Characterization of Vortex Impingement Footprint Using Non-instrusive Measurement Techniques

Investigator(s) (show affiliation): Bianca T. Anderson, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273,
Robert J. Geenen, PRC Systems Services, Ames Dryden Flight Research Facility,
Edwards, CA 93523-0273

Date of report: Oct. 10, 1991 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91:
- In-house: $4,000
- Contracts (identify):
- Grants (identify):

Funds requested for FY92, if any: $40,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

Characterize the on-surface vortex footprint using high-frequency nonintrusive measurement techniques, and develop software to analyze the data.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc. None.

Planned future work

Sensor calibration testing, flight testing, software verification and data analysis.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Bianca T. Anderson Org. Code: XRA MS: D-2045 Phone: (805) 258-3701

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NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Feasibility Study for an X-ray Diffractometry Instrument with X-ray Fluorescence and X-ray Photoelectron Spectroscopy Capabilities for Remote Planetary Missions

Investigator(s) (show affiliation): David F. Blake, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 11, 1991 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $35,000

Estimated expended in FY91: $35,000 Funds requested for FY92, if any: $35,000
- In-house: $25,000
- Contracts (identify): $10,000 (to Dr. Charles Bryson, Surface Interface, Inc.)
- Grants (identify)

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The purpose of this study is to design, fabricate, and test a breadboard instrument prototype of a combined X-ray diffraction and X-ray fluorescence instrument suitable for planetary missions. The information that this instrument collects from a sample (spacings between atomic planes in crystals and major element composition) should allow the mineralogic identification of surface soils and other unconsolidated fine-grained samples.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

In the second year of the project, we will interface a charge-coupled device (CCD) in place of the film cassette in the microfocus X-ray camera. In addition, we will experiment using a second microfocus camera to determine the optimum flux rate for powder diffraction analysis.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: David F. Blake Org. Code: SSX MS: 239-4 Phone: (415) 604-4816

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Radical Measurement by Zeman Spectroscopy (RAMZES): A Prototype Instrument for Airborne In Situ Measurements of Radical Molecular Species

Investigator(s) (show affiliation): T. A. Blake, C. Chackerian, Jr., and J. R. Podolske, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Sept. 27, 1991 Initiation year: FY91 Expected completion date: _____

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91: Funds requested for FY92, if any: $40,000

- In-house: $40,000
- Contracts (identify)
- Grants (identify)

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

The purpose of this work is to develop a laboratory prototype for an ultra-sensitive detector which can be used for the quantitative measurement of free radical molecular species which are found in very low concentrations in the Earth's stratosphere. The laboratory prototype will be used to determine sensitivity limits affected by various of the apparatus' parameters such as magnetic field homogeneity, polarizer efficiency, quality of optical surfaces, and modulating schemes, such that limiting factors can be understood.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Simultaneous two species detection using both right and left polarizations (for noise reduction) for each molecular species.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Charles Chackerian, Jr. Org. Code: SGP MS: 245-4 Phone: (415) 604-6300

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Polarization Measurement of the Infrared Emission Bands from PAH Molecules

Investigator(s) (show affiliation) Jesse Bregman and Yvonne Pendleton, Ames Research Center, Moffett Field, CA 94035-1000
Michael Werner, Jet Propulsion Laboratory, Pasadena, CA

Date of report Oct. 1991 Initiation year FY89 Expected completion date FY91

Funding total prior to FY91 $28,000 Funding authorized in FY91 $35,000

Estimated expended in FY91: $35,000 Funds requested for FY92, if any _____
In-house $19,000
Contracts (identify)
Grants (identify) $16,000 University Consortium with D. Rank, UCSC

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds? No FY92 funds.

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

To measure the polarization from polycyclic aromatic hydrocarbons (PAH) molecules in order to determine

1. if in fact the molecular emission is from PAHs.
2. if the emission bands in the 3.3-3.4 micron region are from the same bonds in the molecules.

The main activity has been devoted to developing infrared array technology, specifically array cameras, to allow the observations to be performed.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Photograph of the galactic center appeared on the cover of Laser Focus World magazine and a short article was published in the magazine. A paper has been submitted to the Astrophysical Journal entitled "Extended PAH Emission Around Infrared Astronomical Satellite IRAS 21282 + 505" which includes data from the camera developed during this project.

Planned future work

We will continue to improve the performance of the cameras and use them for astronomical observations both from the ground and the Kuiper Airborne Observatory. We will also pursue polarization measurements of PAH emitting regions to determine if PAH emission is indeed polarized.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Jesse Bregman Org. Code SSA MS 245-6 Phone (415) 604-6136

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Feasibility of Light Emitting Diode Arrays as a Lighting Source for Plant Growth Chambers in Space

Investigator(s) (show affiliation): David Bubenheim, Raman Sargis, David Wilson, Mark Turner, and Peter Haddeland, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Jan. 1992 Initiation year: FY90 Expected completion date: FY92

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91: $35,000
- In-house $35,000
- Contracts (identify)
- Grants (identify)

Funds requested for FY92, if any: ____

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): 199-61/107-20

to Program (name?): CELSS/SSF Centrifuge Project to Other (identify): ____

Purpose of investigation

To determine if light emitting diodes (LED) offer the potential solution to problems of power consumption, light intensity, volume, and maintainability which plague the design of all lighting systems for space-based, plant growth chambers.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Biological testing with LED arrays engineered during the initial 18 months of DDF-supported work is in progress during the last 6 months of the project and will continue with support from other sources to fully define the potential for application.

A report is in preparation which describes the engineering aspects and preliminary biological results of our work. Presentation of final results is planned for the 1992 meeting of the American Society for Gravitational and Space Biology.

A poster presentation at the ARC Annual DDF Happy Hour describing initial biological results from the LED studies was selected as one of a small number (approximately 6) for display at Dryden.

Planned future work

Determine acceptability of LED arrays in meeting experimental requirements for conducting Space Biology and Controlled Ecological Life Support Systems (CELSS) related plant research.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: David Bubenheim Org. Code: SAR MS: 239-11 Phone: (415) 604-3209

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Plasma Spraying of Nonoxide Ceramic Coatings Using a Constricted Arcjet

Investigator(s) (show affiliation) Jeffrey D. Bull and Paul Kolodziej, Ames Research Center, Moffett Field, CA 94035-1000

Date of report Oct. 24, 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $25,000

Estimated expended in FY91: $25,000 Funds requested for FY92, if any $40,000

In-house	$6,580	Materials plus sample analysis
Contracts (identify)	$18,420	$16,220 (Constricted Arc-Jet Plasma Spraying Services (3 days), Aerotherm Corp., Mountain View, CA) and $2,200 (Fluidized Bed Power Feeder Rental and Support, Babitt Bearing Co., Inc., San Jose, CA)
Grants (identify)		

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

1. To demonstrate that a cohesive and adherent zirconium diboride (ZrB_2) coating can be plasma sprayed using a constricted arc plasma (CAP).
2. To illustrate the advantages of CAP relative to conventional low-pressure plasma spraying by showing that (a) the diboride coating retains the stoichiometry of the original power; (b) a higher degree of control of the plasma effluent can be maintained resulting in reproducible coatings; (c) a much higher throughput can be achieved; and (d) this process produces coatings with improved properties.
3. To show the benefits of hot-wall versus cold-wall plasma spraying.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The project was funded in June 1991. Since that time the necessary arrangements (contracts and purchases) were made. Preliminary studies of the plasma-spraying process in a constricted arc have been completed. Initial parameters for CAP spraying have been generated.

Planned future work

Our arrangement with Aerotherm Corp. is such that we are to "piggy back" on an experiment. When a slot opens up (present - June 1992) we will do our experiments, analyze the coatings and write up the results.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

No narrative report

Prepared by Jeffrey D. Bull Org. Code RTM MS 234-1 Phone (415) 604-5377

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Origin of Life: Exploration of Water/Air Interface as a Reaction Zone for Condensations

Investigator(s) (show affiliation): Sherwood Chang, Ames Research Center, Moffett Field, CA 94035-1000
Anastassia Kanavarioti and Michael Stronach, University of California, Santa Cruz, CA 95064

Date of report: Oct. 4, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91: $40,000
- In-house: $7,000
- Contracts (identify): $33,000 (NCA 2-650)
- Grants (identify):

Funds requested for FY92, if any: $27,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

To examine whether water/air interfaces on the early Earth (such as occur in bubble formation at the sea surface, in thermal springs and subaqueous natural gas vents, in cloud droplets, and aerosols) influenced the synthesis of biologically important molecules.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The work was started in June and only preliminary results are available at this point.

Planned future work

To test reactions such as (i) condensation of amino acides to peptides, (ii) condensation of glycerol, phosphate and fatty acids to form phospholipids, and (iii) fixation of carbonate to formaldehyde or formic acid, in the presence and in the absence of water/air interfaces. To establish the effect of the latter on reaction rates and product distribution.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: A. Kanavarioti Org. Code: SSX MS: 239-4 Phone: (415) 604-5733

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Human Exploration Demonstration Project

Investigator(s) (show affiliation): Edward Chevers and David Korsmeyer, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: 2/21/92 Initiation year: FY91 Expected completion date: FY94

Funding total prior to FY91: _____ Funding authorized in FY91: $242,000

Estimated expended in FY91:
- In-house: $242,000
- Contracts (identify):
- Grants (identify):

Funds requested for FY92, if any: $227,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The Human Exploration Demonstration Project (HEDP) is a multi-Division effort to address the advanced technology requirements necessary to implement an integrated working and living environment for a planetary surface habitat.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The lunar terrain simulator and the robotic rover systems were demonstrated for the Automation Sciences Research Facility (ASRF) dedication ceremony.

Planned future work

Continued development of the HEDP living and working environments.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: David J. Korsmeyer Org. Code: FI MS: 269-1 Phone: (415) 604-3114

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Propulsion Instrumentation Research Chamber (PIRC)

Investigator(s) (show affiliation) Timothy R. Conners, L. Dean Webb, Sheryll A. Powers, and Ronald J. Ray,
Ames Dryden Flight Research Facility, Edwards, CA 93523-0273

Date of report Oct. 7, 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $35,000

Estimated expended in FY91: $35,000 Funds requested for FY92, if any $35,000
In-house $4,000
Contracts (identify) $3,000: PRC Inc., $28,000: King Weld
Grants (identify)

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

The primary purpose of our investigation was to develop a facility for testing advanced instrumentation for use in propulsion systems. The PIRC has been designed to be mounted ahead of an F100 turbofan engine mounted in a ground test stand (a type of pseudo inlet). Propulsion-type sensors can be easily attached to the PIRC and exposed to the air-stream entering the engine. Installation techniques, signal quality, and sensor response to the real engine environment will be studied. The PIRC will be used as a low-cost method to accelerate the transition of propulsion instumentation, including nonintrusive laser-based sensors, to flight use.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The PIRC is currently being manufactured and is scheduled for delivery to Dryden at the end of this month.

Planned future work

The F-18 HARV program as well as Pratt & Whitney have shown interest in using the PIRC to test new types of instumentation. In addition, more generic type research is planned using nonintrusive laser systems. The feasibility and usefulness of using lasers in the propulsion environment will be studied. Additional funding is requested to offset engine fuel and other test costs and to procure pressure and temperature transducers as well as additional analysis equipment.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Timothy R. Conners Org. Code XFP MS D-2112 Phone (805) 258-3324

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Scheduling Electrical Power for Ames Research Center

Investigator(s) (show affiliation): Megan Eskey, Ames Research Center, Moffett Field, CA 94035-1000
Kimbal Collins, Sterling Software
Robin Orans, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 10, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $53,000

Estimated expended in FY91: Funds requested for FY92, if any: $100,000

In-house: GS-13 at 10 hr per week GS-14 at 10 hr per month
Contracts (identify): Sterling NAS-2-13210, Task 013, 44 K
Grants (identify):

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): R&D 5055929, R&D 5055984, and R&PM 30-02-80P: Non-energy utility funds

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The objective of this work was to study the application of constraint-based scheduling and iterative improvement optimization techniques to the wind tunnel operations domain. Aerodynamic testing at Ames costs on the order of $1 million per month in electrical power. Reduction of power and other costs is achieved by scheduling tests in such a way as to optimize soft constraints, such as schedule lengths and power cost, while satisfying hard constraints such as wind tunnel availability.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

A brief overview of this work was presented at the Information Sciences Applications to Aeronautics Workshop in July 1991.

Planned future work

Continuation of work described above.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Megan Eskey Org. Code: FIA MS: 244-17 Phone: (415) 604-4863

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation A Resonant Ge:Ga Far Infrared Photoconductor

Investigator(s) (show affiliation) Jam Farhoomand, Orion TechnoScience, Palo Alto, CA
Robert E. McMurray, Jr., Ames Research Center, Moffett Field, CA 94035-1000

Date of report Oct. 8, 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $35,000

Estimated expended in FY91: Funds requested for FY92, if any $40,000

In-house $25,000
Contracts (identify) $10,000, Lawrence Berkeley Laboratory
Grants (identify)

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

An experimental feasibility study of fabricating a resonant Ge:Ga far infrared photoconductor with enhanced characteristics such as unit quantum efficiency, improved photoconductive gain, responsivity, and noise equivalent power.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

*Theoretical study completed

*Initial preparation of germanium test wafers according to the required specifications has been successfully completed.

*The test dewar, including the necessary optical components and electronic circuitry, has been assembled.

*A patent disclosure has been filed with the Ames patent office. Filing an application is currently under way.

*Following manuscripts have been published: 1) J. Farhoomand and R. E. McMurray, "A resonant IR Photoconductor with Unit Quantum Efficiency," Proc. 16th Int. Conf. on IR & MM Waves (1991), 2) J. Farhoomand and R. E. McMurray, "Design Parameters of a Resonant IR Photoconductor with Unity Quantum Efficiency," Appl. Phys. Lett. 58, 622, 1991. Complete fabrication of detector. Conduct tests to evaluate detector performance.

Planned future work

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Jam Farhoomand/Robert McMurray Org. Code SFO MS 244-10 Phone (415) 604-3412

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Fully Coupled Structural Deformations and Computational Fluid Dynamics: Direct Solutions Using Newton's Method

Investigator(s) (show affiliation): Fort F. Felker, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Sep. 19, 1991 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91:
- In-house: $40,000
- Contracts (identify):
- Grants (identify):

Funds requested for FY92, if any: $40,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The objectives of this research are to: (1) develop a procedure for the direct solution of static aeroelasticity problems, and (2) to investigate the accuracy, efficiency, and convergence properties of the method for representative model problems.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Interim results were published as: "Fully-Coupled Structural Deformations and Computational Fluid Dynamics: Direct Solutions Using Newton's Method," by Fort F. Felker, Proceedings of the 4th International Symposium on Computational Fluid Dynamics, Davis, California, September 1991.

Planned future work

Future work will extend both the structural and fluid dynamics models. The fluid dynamics will be extended to use the Navier-Stokes equations, and the structural model will be extended to use a finite element method.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Fort F. Felker Org. Code: FFR MS: T-042 Phone: (415) 604-6096

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Immunological Effects of Gravitational Stress and Simulated Microgravity

Investigator(s) (show affiliation): Danielle Goldwater, Ames Research Center, Moffett Field, CA 94035-1000; Diether Recktenwald, Becton Dickinson Immunocytometry Systems, San Jose, CA 95131; Robert Bargatze and Margo Peacock, Stanford University, Stanford, CA; Joan Vernikos, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Nov. 21, 1991 Initiation year: FY90 Expected completion date: FY92

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91: $30,000 Funds requested for FY92, if any: ____

- In-house: $15,000
- Contracts (identify): $5,000 Bionetics $3,000 Becton Dickinson
- Grants (identify): $7,000 (JRI - Univ. Louisville)

Status of study: ☒ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?): 142-20

to Program (name?): ____ to Other (identify): ____

Purpose of investigation

To adapt flow cytometry/monoclonal antibody technology in order to assess the impact of postural (orthostatic) gravitational stress and bed rest simulation of spaceflight on the immune system. The working hypothesis is that prolonged spaceflight induces immunosuppression. A reliable technique is required to serially monitor such changes and increase scientific understanding of the immunological adaptation to long duration spaceflight.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Highly successful investigation. Demonstrated sensitivity and reliability of flow cytometry technology to detect subtle transient, progressive changes in immune cell populations during 15 minutes of standing, as well as changes after 7 days of bed rest simulation of microgravity in Ames Human Research Facility. Also, since whole blood often not available, developed technique for use of residual white blood cells ("buffy coat") from "throw away" portion of sample remaining after plasma harvesting. Results applicable to:

1. Blood sampling and analysis in the microgravity or office environment when whole blood isn't available;
2. Development of a reliable ground-based research model for the immunological adaptation to spaceflight;
3. Improved interpretation of post-flight immune system changes (microgravity vs. re-entry stress);
4. Understanding of immune system responses to autonomic stress and bedrest inactivity with possible implications for insight in immunosuppressive disorders such as AIDS; and
5. Potential application to the general phenomenon of opportunistic infections and immunosuppression in bedridden or hospitalized patients. Papers in preparation.

Award

Selected by Ames Basic Research Council as one of 8 best research posters for FY91.

Planned future work

Interpretation of orthostatic results in context of endocrine changes. Analysis of data obtained during 3 additional ARC studies (J. Vernikos, PI) involving countermeasures. Specific study to verify whole blood vs. residual buffy coat technique. Extend results in new bed rest, countermeasure, acceleration and spaceflight studies.

Prepared by: Dani Goldwater Org. Code: SL MS: 223-3 Phone: (415) 604-4044

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Initiating a Model System Using Skin Cells to Study Spaceflight-Related Aging and Senescence

Investigator(s) (show affiliation): Rose Grymes and Joan Vernikos, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 3, 1991 Initiation year: FY90 Expected completion date: FY92

Funding total prior to FY91: $29,807 Funding authorized in FY91: $31,874

Estimated expended in FY91: $31,874 Funds requested for FY92, if any: ____

In-house: $17,118.15

Contracts (identify):

Grants (identify): $14,755.85 NASA-Ames University Consortium Joint Research Interchange (NCA2-483)

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?): ____

to Program (name?): ____ to Other (identify): ____

Purpose of investigation

We have investigated growth factor responsiveness, cell cycle regulation, and transcriptional control in a strain of senescent cells (Werner's syndrome) and in normal cells. Werner's syndrome is an autosomal recessive disorder characterized by specific precocious aging. Pathologic changes occur in the skin and connective tissue. The regulated expression of matrix metalloproteases, like collagenase I, is a critical function in skin cells. Cultured Werner's syndrome skin cells show a unique defect in collagenase I expression. Some animal cell behaviors following spaceflight or simulated microgravity mimic those of aging.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Awards: Best Postdoctoral Research, Western Regional Meeting, Society for Investigative Dermatology, 1991.

Papers presented: Regulation of the Collagenase I Gene in Werner's Syndrome, R. A. Grymes, Western Regional Meeting, Society for Investigative Dermatology, Feb. 1991.[1]

Type I Collagenase Gene Regulation in Werner's Syndrome Fibroblasts, R. A. Grymes, National Meeting, Society for Investigative Dermatology, May 1991. [2]

Planned future work

Publication: Induction and suppression of collagenase I synthesis in a progeroid cell strain, R. A. Grymes, J. Altman, J. Chan, P. Suen, E. A. Bauer, manuscript in preparation.

Proposal submitted: Space Biology Program, Code SBR, NASA Headquarters, Sep. 1, 1991.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Not applicable

[1]Published in Clinical Res. 39(1), R. A. Grymes, J. Chan, P. Suen, E. A. Bauer, 1991.

[2]Published in J. Invest. Derm. 96(4):539, R. A. Grymes, J. Chan, P. Suen, E. A. Bauer, 1991.

Prepared by: Rose Grymes Org. Code: SL MS: 239-11 Phone: (415) 604-3239

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Domain Decomposition Approach to Solve Multidisciplinary Fluid/Structure Interaction Problems

Investigator(s) (show affiliation): Guru P. Guruswamy, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 7, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: $40,000 Funding authorized in FY91: $40,000

Estimated expended in FY91:
In-house
Contracts (identify)
Grants (identify): A new grant to MCAT Institute (in-house)

Funds requested for FY92, if any: $40,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

Develop efficient interfacing techniques between fluid zonal grids and structural sub-domains (sub-structures). These new interface techniques will be tested on simple model problems. Procedures to use this development to solve larger three-dimensional problems associated with complex geometries, such as full aircraft, will be addressed at the end of the research.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc

During this period, interfacing techniques are developed for wing-type configurations. The flow is modeled using the finite-difference (FD) method with a single C-H type grid. The structural properties of the wing are modeled using a finite-element (FE) wing-box-type model in which the surface of the wing is modeled using triangular membrane elements. An interfacing routine to transfer information from FD fluid's grid to FE structural grid is developed. Thermal stresses are computed for supersonic flow conditions. This demonstrates the use of the present development for configurations that can be modeled using single zones.

Planned future work

This work will be extended for wing-body configurations with two sub-structures, one for the wing and another for the body. First, results will be demonstrated for a single-zone FD grid and two-zone structural FE model.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Guru P. Guruswamy Org. Code RFA MS 258-1 Phone (415) 604-6329

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation An Iterative Image Rectification Scheme for Observational Astronomy

Investigator(s) (show affiliation) Michael R. Haas, Ames Research Center, Moffett Field, CA 94035-1000
Steven D. Lord, University of California, Santa Cruz, CA

Date of report Oct. 1991 Initiation year FY90 Expected completion date FY91

Funding total prior to FY91 $23,000 Funding authorized in FY91 $35,000

Estimated expended in FY91:
In-house
Contracts (identify)
Grants (identify) $35,000

Funds requested for FY92, if any

Status of study ☐ Completed in FY91 ☒ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) to Other (identify)

Purpose of investigation

To explore the use of a numerical image rectification scheme which has the ability to remove the loss of spatial resolution caused by a telescope's aperture.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

"MIPS Polarimetry: Considerations in Using a Wollaston Prism for Extended Source Observation." Report of SIRT Polarimetry Working Group.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Under Contract with the SIRTF Polarimetry Working Group (G. Rieke, U. AZ).

Prepared by Michael R. Haas Org. Code SSA MS 245-6 Phone (415) 604-5511

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Remote Sensing of Earth's Atmosphere and Surface Using a Digital Array Scanned Interferometer

Investigator(s) (show affiliation) Philip D. Hammer, Francisco P. J. Valero, and David L. Peterson,
Ames Research Center, Moffett Field, CA 94035-1000
William Hayden Smith, Washington University, St. Louis, MO

Date of report Oct. 10, 1991 Initiation year FY91 Expected completion date FY93

Funding total prior to FY91 _____ Funding authorized in FY91 $45,000

Estimated expended in FY91: Funds requested for FY92, if any $25,000

In-house $23,000
Contracts (identify) $22,000 (Consortium agreement with Washington University; $11,000 of this amount is an advance to cover FY92)
Grants (identify)

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

The objective of our study is to evaluate the capabilities of the DASI class of instruments for measuring terrestrial radiation fields, particularly in the visible to mid-infrared. DASIs are capable of high throughput, sensitivity, and spectral resolution, and have the potential for field-of-view spatial discrimination (an imaging spectrometer). Thus they have much potential as future-generation remote sensing instruments. The ultimate objective stemming from this study is to produce and deploy a versatile field instrument which may be applied toward a variety of atmospheric and surface problems.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

- Seminar given at Oregon State University, Corvallis, OR, November 1990
- Poster and abstract at Airborne Geoscience Workshop, San Diego, CA, January 1991
- Discussion of DASI applications for vegetative canopy studies was held at the workshop on remote sensing of plant biochemical content, Marshall, CA, March 1991
- Article on DASI potenials and applications submitted to Journal of Imaging Science, October 1991
- Abstract accepted for AGU meeting, San Francisco, CA (to be held December 1991)

Planned future work

Intensive instrument development work is planned for FY92. Application of DASIs for remote sensing of plant biochemical content is being studied and opportunities such as the Biome sensor (being formulated at NASA Ames) are being explored. We have initiated a collaboration with an atmospheric lidar group for informal participation in project FIRE, which could yield coordinated multi-sensor measurements of cirrus clouds leading to a case study. A specific approach for retrieving information about clouds from spatially and spectrally (1-2.5 micron) resolved measurements of the solar aureole is being explored.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Philip D. Hammer Org. Code SGP MS 245-4 Phone (415) 604-3383

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Fault Tolerance in Distributed Parallel Processing Architectures for Flight Crucial Systems

Investigator(s) (show affiliation): Philip Hamory, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273

Date of report: Oct. 1991 Initiation year: FY90 Expected completion date: FY91

Funding total prior to FY91: $35,000 Funding authorized in FY91: _____

Estimated expended in FY91:
- In-house
- Contracts (identify)
- Grants (identify)

Funds requested for FY92, if any: _____

Status of study: ☒ Completed in FY91 ☐ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

To study the fault tolerance of transputer-based networks for use in flight crucial systems.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Philip Hamory Org. Code: XRF MS: D-2205 Phone: (805) 258-3090

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Development and Experimental Verification of a Noninvasive Intracranial Pressure Recording System

Investigator(s) (show affiliation): Alan R. Hargens, Ames Research Center, Moffett Field, CA 94035-1000;
Gita Murthy, Bionetics; Robert J. Marchbanks, University of Southhampton; and
Donald E. Watenpaugh, Bionetics

Date of report: Oct. 10, 1991 Initiation year: FY90 Expected completion date: FY91

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91:
- In-house: $10,645
- Contracts (identify): $24,355
- Grants (identify):

Funds requested for FY92, if any: ____

Status of study: ☒ Completed in FY91 ☐ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____ to Other (identify) ____

Purpose of investigation

To examine alterations of intracranial pressure during simulated microgravity, in humans, using a noninvasive tympanic membrane displacement technique.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

- The results were presented at the 13th annual IUPS meeting, San Antonio, Texas.
- Abstract - The Physiologist 34:257(48.1), 1991
  Manuscript - The Physiologist 36 (supplement), 1992

Planned future work

- Flybidize the noninvasive device
- Utilize this technique to study long term effects of simulated microgravity on intracranial pressure

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Gita Murthy Org. Code: SL MS: 239-11 Phone: (415) 604-5747

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation An Airborne Infrared Scanner for Wild Fire Mapping and Monitoring

Investigator(s) (show affiliation) Edward A. Hildum, James Brass, and Mark Haslerud,
Ames Research Center, Moffett Field, CA 94035-1000
Robert Higgins, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273

Date of report Oct. 1991 Initiation year FY90 Expected completion date FY92

Funding total prior to FY91 $35,000 Funding authorized in FY91 $35,000

Estimated expended in FY91:
In-house $35,000
Contracts (identify)
Grants (identify)

Funds requested for FY92, if any

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) to Other (identify) Support through Riverside Fire Lab.

Purpose of investigation

Designing and building a low cost multichannel digital scanner for monitoring the impacts of wild fire on ecosystem and atmospheric processes with potential application for fire management and mapping.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

- Terra-Mar press release: "Terra-Mar and NASA Collaborate on Natural Disaster Assessment," Jan. 23, 1991.
- J. Brass, E. Hildum, and P. Riggan, "Use of Remote Sensing Technology for Fire Management Applications," Proceedings of the National Fire Management Conference, Woodside, CA, May 1991.
- D. Walklet, "Fighting Forest Fires with Remote Sensing," Photonics Spectra, Aug. 1991, p. 66.

Planned future work

Complete assembly and testing by Mar. 1992. Deploy the scanner on the Los Angeles County Navajo aircraft. Fly scanner in Brazil in July and/or Sept. 1992 on NCAR King-Air or Ames C130.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by E. Hildum/J. Brass Org. Code EES MS 213-15 Phone (415) 604-4069

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Intelligent Dynamic Scheduling Algorithms for Automatic Telescopes

Investigator(s) (show affiliation): Butler Hine, Mark Drummond, John Bresina, Keith Swanson, Andy Philips, Rich Levinson, and Bill Borucki, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 28, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $35,000

Estimated expended in FY91: $35,000
- In-house: $8,400
- Contracts (identify): $24,600 AutoScope Corp.
- Grants (identify):

Funds requested for FY92, if any: $40,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

There are many NASA mission scenarios in which the unattended autonomous operation of a scientific instument is desired because of the expense of an in-situ human operator. This is especially true for astronomical observations, in which the method of data acquisition is well suited to automatic operation. This project is an attempt to transfer current state-of-the-art technology in the areas of intelligent scheduling and health monitoring to the operation of fully automated telescopes, thereby increasing their efficiency and robustness.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Applications: A prototype Interactive Scheduling Tool was used to prepare a fall 1991 observing sequence for anoperating Automated Photoelectric Telescope (APT).

Developments: An Automatic Telescope simulator was developed for use in software development.

Papers: "Development of a simplified operations and management structure" B. Hine 1990 Workshop on Small Robotic Telescopes on the Moon. "The APT Planning and Scheduling Manifesto" M. Drummond, J. Bresina, K. Swanson, A. Philips, R. Levinson, 1991 NASA ARC TR# FIA-91-24. "Multi-use Lunar Telescopes" Genet, Genet, Talent, Drummond, Hine, Boyd, Trueblood, in preparation.

Planned future work

Benchmark performance increase in the use of new scheduling algorithms in existing control systems. Hold a workshop on the testing of an autonomous telescope in Antarctica as a lunar mission precursor. Apply scheduling algorithms to field use and measure their performance.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Butler Hine Org. Code: FIC MS: 269-3 Phone: (415) 604-4379

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Control of Thermal Simulation Tests with Heat Flux

Investigator(s) (show affiliation): Thomas J. Horn, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273

Date of report: Oct. 18, 1991 Initiation year: FY90 Expected completion date: FY95

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91:
- In-house: $35,000
- Contracts (identify):
- Grants (identify):

Funds requested for FY92, if any:

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): 505-63

to Program (name?): to Other (identify):

Purpose of investigation

Develop the ability to use heat flux sensors for data acquisition and/or control of thermal simulation tests in the Thermostructures Research Facility and Liquid Hydrogen Structures Test Facility. This includes the identification and establishment of appropriate sensor specifications, calibration methods, and data acquisition and control system hardware and software.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

1. Poster presentation at the 1st Thermal Structures Conference at the University of Virginia
2. Influencing the design of the next generation Data Acquisition and Control System being developed for the Thermostructures Research Facility and Liquid Hydrogen Structures Test Facility.
3. Added capability to generate step changes in heat flux with the existing Data Acquisition and Control System.

Planned future work

1. Continue evaluation of heat flux sensors at high temperatures and flux levels.
2. Develop the heat flux calibration facility as an operational tool.
3. Use heat flux sensors on Generic Research Cryogenic Tank.
4. Evaluate fiberoptic sensors

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Thomas J. Horn Org. Code: XRS MS: D-48202A Phone: (805) 258-2232

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Development of a Si(Li) Gamma Ray Detector Stack for Future Mars Mission Instruments

Investigator(s) (show affiliation): G. Scott Hubbard, R. E. McMurray, Jr., C. P. McKay, R. Keller, and P. Wercinski, Ames Research Center, Moffett Field, CA 94035-1000
P. Englert, San Jose State University, San Jose, CA

Date of report: Oct. 11, 1991 Initiation year: FY90 Expected completion date: FY91

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91:
- In-house $35,000
- Contracts (identify)
- Grants (identify)

Funds requested for FY92, if any: ____

Status of study: ☒ Completed in FY91 ☐ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____ to Other (identify) ____

Purpose of investigation

Develop, test, and compare to numerical model predictions, a novel lithium-drifted Silicon [Si(Li)] gamma-ray detector package. A large-scale, flight version of this detector package would be a key element in an elemental measurement for future Mars missions. Use of Si will allow operation at ambient Mars temperature, an enormous advantage when compared to proposed germanium gamma ray detectors which require cooling to ~100K. Development of this detector package would provide high resolution detection of gamma ray with energies in the million electron volt (MeV) range, a unique accomplishment for Si(Li) devices.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Paper accepted for presentation at Nuclear Science Symposium, November 4-9, 1991.

Planned future work

Continue measurements of resolution as a function of temperature; propose further efforts to NASA HQ, Code SL and Code RC; submit proposal to PIDDP Research Announcement in December 1991.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: G. Scott Hubbard Org. Code: SFI MS: 244-10 Phone: (415) 604-5697

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Controlling the Lifetime and Reaction Dynamics of High Energy Density Materials (HEDM) by Modifying the Chemical Environment

Investigator(s) (show affiliation): Winifred M. Huo, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 11, 1991 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91: Funds requested for FY92, if any: $40,000

In-house: $38,000 Convex computer support, $2,000 NCD terminal

Contracts (identify)

Grants (identify)

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

This project investigates how the chemical environment can be modified to stabilize potential HEDM candidates and to harvest their energy for propulsion. FN_3 and Td N_4 are two prototype molecules used to illustrate the general principle.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The results of this investigation were presented at the workshop on "Performance Enhancement for Hypervelocity Airbreathing Propulsion," July 29-31, 1991, at NASA Langley Research Center. The title of the talk is "Enhancement of Hypervelocity Propulsion From a Computational Chemistry Viewpoint."

This proposal received the Jack N. Nielson award.

Planned future work

A detailed study of the dissociation of FN_3, FN_3H_2, FN_3O_2, and FN_3N_2 using CCSD(T) and MCPF methods is in progress. These calculations are designed to benchmark previous CASSCF studies. These methods will also be used to study possible synthesis pathways of TdN_4.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Winifred M. Huo Org. Code: RTC MS: 230-3 Phone: (415) 604-6161

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Team Performance Analysis of Information Flow: Human-Centered Approach to Studying Aerospace Groups

Investigator(s) (show affiliation): Barbara G. Kanki, Ames Research Center, Moffett Field, CA 94035-1000
Mary Danz, University of Central Florida

Date of report: Oct. 10, 1991 Initiation year: FY90 Expected completion date: FY92

Funding total prior to FY91: $30,000 ($15,000 DDF) Funding authorized in FY91: $135,000 ($35,000 DDF)

Estimated expended in FY91: Funds requested for FY92, if any: $75,000

In-house $100,000
Contracts (identify)
Grants (identify) $35,000 University of Central Florida

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☒ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of Investigation

To develop a methodology for evaluating team performance and tracking information flow using payload operations at Kennedy Space Center (KSC) (Level IV experiments integration) as a testbed for identifying effective communication strategies and for developing aids for information management. Testbed results and methodology will then be assessed for their transfer into both airline transport maintenance and shuttle operations.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Invited presentation entitled "Maintenance Team Performance and Information Flow in Shuttle Processing Operations" at the AIAA/NASA/FAA/HFS Conference: Challenges in Aviation Human Factors: The National Plan, Jan. 1991, Vienna, VA.

Conducted a mini-workshop for researchers working the KSC operational environment, July 1991

1. Modeling the NASA Test Director/Remington, Kessel, ARC
2. Information Flow and Team Performance during Mission Sequence Test: Communication Analyses/Kanki, Elsbach, Veinott, Irwin, ARC and MST Procedure Aids/Danz, University of Central Florida
3. Multi-cultural Work Groups at KSC/Reyes, UC Santa Barbara
4. Astronaut Science Advisor: Lessons Learned/Statler, ARC

Planned future work

Extension of methodology into other aerospace operational environments: collaboration with KSC in orbiter processing facility; collaboration with Danz, University of Central Florida, with aircraft maintenance teams.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Barbara Kanki Org. Code FLT MS 262-4 Phone (415) 604-5785

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Development of Experimental Techniques for Thermoelastic Vibration Testing

Investigator(s) (show affiliation): Michael W. Kehoe, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273
H. Todd Snyder, PRC Systems Services

Date of report: Oct. 10, 1991 Initiation year: FY89 Expected completion date: FY91

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91: Funds requested for FY92, if any:

In-house

Contracts (identify): $35,000 (PRC - Support Engineering)

Grants (identify)

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?):

to Program (name?): NASP to Other (identify):

Purpose of investigation

The objective was to research and develop experimental techniques to conduct vibration testing on structures subjected to high temperatures.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Reports/Publications

1. High Temperature Ground Vibration Test Techniques
2. Determination of the Effects of Heating on Modal Characteristics of an Aluminum Plate With Application to Hypersonic Vehicles.

Planned future work

Testing of more complex materials

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Mike Kehoe Org. Code: XRDV MS: D-2112 Phone: (805) 258-3708

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Application of Video Imaging for Data Acquisition and Processing of Rotorcraft Flow Visualization

Investigator(s) (show affiliation) Cahit Kitaplioglu, Ames Research Center, Moffett Field, CA 94035-1000
Alexandra Swanson, Sterling Software
John Bluck, Ames Research Center, Moffett Field, CA 94035-1000

Date of report Oct. 10, 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $25,000

Estimated expended in FY91:
In-house
Contracts (identify) $25,000
Grants (identify)

Funds requested for FY92, if any _____

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) 505-59-36 (G. Unger, Code RF)

to Program (name?) Advanced Concepts to Other (identify) _____

Purpose of investigation

The objective of this study is to implement an imaging system capable of supporting various flow visualization methodologies (such as the wide-field shadowgraphy technique and smoke flow visualization) for real-time data acquisition and storage of high resolution flow field structures. This research will have a Center-wide impact by making new and innovative imaging technology available for basic fluid dynamics research on vortex instabilities and breakdown studies.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The system is currently installed in the 40- by 80-Foot Wind Tunnel and is being checked out to verify asynchronous image capture for various rpm conditions. Full frame image acquisition and high resolution image quality are also being examined. Modification will be made to the image processing software in order to automate data reduction of the simultaneously acquired image pairs. Image pairs will be used to resolve accurate three-dimensional rotor wake measurements.

Planned future work

Once the system is completely checked out, it will be readied for shadowgraph and smoke flow visualization testing to examine the detailed wake structure for upcoming tests in the National Full-Scale Aerodynamics Complex.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Alexandra Swanson Org. Code FFR MS T-042 Phone (415) 604-6856

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Stanford University-NASA Ames Research Center Global Change Institute

Investigator(s) (show affiliation): James G. Lawless, Ames Research Center, Moffett Field, CA 94035-1000
W. Gary Ernst, Stanford University

Date of report: Oct. 31, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $42,500

Estimated expended in FY91:
In-house
Contracts (identify)
Grants (identify)

Funds requested for FY92, if any: _____

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation
Initiate joint Stanford University-NASA Ames Research Center Global Change Institute studies.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.
(See narrative in this report).

Planned future work
Continuation plus proposal writing.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by James G. Lawless Org. Code SG MS 239-20 Phone (415) 604-5900

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: The Search for Interstellar Molecules in Carbonaceous Meteorites

Investigator(s) (show affiliation): Narcinda R. Lerner and Sherwood Chang,
Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91:
In-house $40,000
Contracts (identify)
Grants (identify)

Funds requested for FY92, if any: $40,000

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation
To measure the D/H ratio of organic compounds in meteorites.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work
Measuring D/H ratio of organic compounds in meteorites.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

No narrative report

Prepared by Narcinda R. Lerner Org. Code RTC MS 239-4 Phone (415) 604-6941

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Surface Temperature Field Mapping by Luminescence Imaging

Investigator(s) (show affiliation) B. G. McLachlan, Ames Research Center, Moffett Field, CA 94035-1000
J. H. Bell, J. Gallery, M. Gouterman, and J. B. Callis, University of Washington

Date of report Oct. 1991 Initiation year FY90 Expected completion date FY92

Funding total prior to FY91 $37,400 Funding authorized in FY91 $32,600

Estimated expended in FY91: Funds requested for FY92, if any

In-house $16,300
Contracts (identify) $16,300 (M. Gouterman and J. B. Callis, Univ. of Washington)
Grants (identify)

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) to Other (identify)

Purpose of investigation

Assess the feasibility of developing a temperature sensitive luminescent paint for surface temperature field measurement in aerodynamic testing that is compatible with the previously developed pressure sensitive luminescent paint.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Report in preparation.

Planned future work

Incorporate the temperature sensitive material into the pressure sensitive paint producing one coating capable of simultaneous pressure and temperature field measurement.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by B. G. McLachlan Org. Code RFR MS 260-1 Phone (415) 604-4142

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation The Laser Digitizer Project

Investigator(s) (show affiliation) Marshal L. Merriam and Timothy J. Barth, Ames Research Center, Moffett Field, CA 94035-1000

Date of report Oct. 11, 1991 Initiation year FY90 Expected completion date FY92

Funding total prior to FY91 $35,000 Funding authorized in FY91 $35,000

Estimated expended in FY91: $35,000
In-house $21,339
Contracts (identify)
Grants (identify) $8,326 SJSU/NASA Ames R&D Program
$5,335 Consortium: Iowa State NCA2-596

Funds requested for FY92, if any

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds? No funds needed in FY92

If transitioned to other funding, to RTOP (number?)

to Program (name?) to Other (identify)

Purpose of investigation

To show how a laser digitizer can be used to get surface geometry from models.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

3D CFD in a Day, The Laser Digitizer Project, AIAA-91-1654, Marshal L. Merriam and Timothy J. Barth, AIAA 22nd Fluid Dynamics, Plasma Dynamics and Lasers Conference, June 24-26, 1991, Honolulu, Hawaii.

Surface Reconstruction from scattered data through pruning of unstructured grid. AIAA-91-1584, Catherine M. Maksymiuk and Marshal L. Merriam, AIAA 10th Computational Fluid Dynamics Conference, June 24-27, 1991, Honolulu, Hawaii.

Surface Definition Using Multiple Carpet Plots. Consortium Report, August 1991.

Planned future work

Integration of surface definition with grid generation and flow solvers.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Marshal L. Merriam Org. Code RFTC MS 202A-1 Phone (415) 604-4737

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Detection of Autotrophic Life on Mars by Surveying for Oxygen

Investigator(s) (show affiliation): Bonnie O'Hara, Ames Research Center, Moffett Field, CA 94035-1000
Lynn Rothschild, TGS Technology, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: 10/11/91 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $35,000

Estimated expended in FY91: Funds requested for FY92, if any: $40,000

- In-house: $5,000
- Contracts (identify): $30,000 (TGS Technology)
- Grants (identify):

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The purpose of this investigation is to conduct experiments leading to instrument definition for detecting autotrophic life on Mars. Specifically, the proposed instrument would survey the surface of Mars for a byproduct of photosynthesis, oxygen. This study tests the feasibility of this approach by testing for oxygen evolution from autotrophic microbial communities on Earth.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

One manuscript in preparation: Carbon Fixation in a Cryptic Microbial Mat

Planned future work

Determine the rates of carbon fixation in several other microbial systems under ambient and increased carbon dioxide. Determine oxygen evolution directly from these samples. Determine flight instrumentation compatible with oxygen evolution results.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Lynn Rothschild Org. Code SSS MS 239-12 Phone (415) 604-6525

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Neurocomputer Development for Fast Processing of Massively Parallel Recordings from Brain Cells - Developing a "Brain" to Study the Brain!

Investigator(s) (show affiliation): A. J. Pellionisz and D. L. Tomko, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 21, 1991 Initiation year: FY90 Expected completion date: FY92

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91:
- In-house: $35,000
- Contracts (identify):
- Grants (identify):

Funds requested for FY92, if any: _____

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☒ with funds remaining? = 0 ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

The objective of this project is to develop a prototype neurocomputer for fast processing of simultaneous arrays of neurophysiological data, much as brain circuits do themselves. Such arrays of data arise from simultaneous records of electrical activity from multiple brain cells. A limiting function in this understanding is the analysis of activities of an array of neurons in a network. The neurocomputer prototype assists such parallel data processing. The objective is to combine a conventional microcomputer host with a Transputer parallel processor. Algorithms and software are developed for data analysis and processing based on the tensor network theory of CNS function developed by Pellionisz.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Pellionisz, A. (1991) Discovery of Neural Geometry by Neurobiology and its Utilization in Neurocomputer Theory and Development. Intl. Conf. on Artificial Neural Networks. Helsinki, Finland. T. Kohonen (et al.), eds., North Holland, 485-493.

Pellionisz, A. J. and J. R. Bloedel (1991) Functional Geometry of Purkinje Cell Population Responses as Revealed by Neurocomputer Analysis of Multi-Unit Recordings. Soc. Neurosci. Absts., New Orleans, LA.

Pellionisz, A. and Tomko, D. (1991) Geometrical Aspects of the Vestibulo-Cerebellar Neurocomputer. Palo Alto, CA, B. Cohen, F. Guedry and D. Tomko, eds., New York Academy, *see full list of publications in "narrative."*

Planned future work

Complete software development and prepare publications.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: A. J. Pellionisz Org. Code: SL MS: 261-3 Phone: (415) 604-4821

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Biologically Produced Magnetite and Its Relationship to the Banded Iron Formations

Investigator(s) (show affiliation) Deborah Schwartz, Rocco Mancinelli, and Melisa White, SETI Institute,
Ames Research Center, Moffett Field, CA 94035-1000
Verne Oberbeck, Ames Research Center, Moffett Field, CA 94035-1000

Date of report Oct. 11, 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $33,000

Estimated expended in FY91: Funds requested for FY92, if any $37,500

In-house $9,490
Contracts (identify) $8,448- SETI, $15,062 - SJSU
Grants (identify)

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

The purpose of this investigation is to identify characteristics of biologically produced magnetite and determine if these characteristics are unique to biologically produced magnetite or if they are also typical of magnetite produced abiotically. Additionally, through this study, we will obtain information on the characteristics of magnetite found in the Gunflint Banded Iron Formation and determine the relationship between biologically produced magnetite and the magnetite found in the Gunflint Formation.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Only preliminary results have been achieved thus far. Organisms used in this study take months to grow.

Planned future work

Continue characterization of magnetite extracted from magnetotactic bacteria (Aquaspirillum magnetotacticum and a marine magnetotactic bacteria isolated by us), and from the Gunflint Formation, using electron microscopy and energy dispersive X-ray analysis, X-ray diffraction, and differential thermal analysis. Compare and contrast results obtained. Continue literature study of magnetite found in other Banded Iron Formations. Determine relationship between biologically-produced magnetite and magnetite found in the Banded Iron Formations.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Deborah Schwartz Org. Code SSS MS 239-12 Phone (415) 604-3668

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Development of a Direct Measurement Transducer for the Oil Wedge Skin-Friction Technique

Investigator(s) (show affiliation): H. Lee Seegmiller, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 10, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: _____ Funding authorized in FY91: $35,000

Estimated expended in FY91:
- In-house
- Contracts (identify) $12,563.00 (instrument purchases)
- Grants (identify)

Funds requested for FY92, if any: _____

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☒ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

Develop new technology to obtain skin-friction measurements in locations and conditions not now accessible.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

For studies terminated before FY91 (any accomplishments/applications not previously reported)

No narrative report

Prepared by H. Lee Seegmiller Org. Code RFE MS 229-1 Phone (415) 604-6211

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Accelerated Overset Grid Generation for Rapid Design Studies with CFD

Investigator(s) (show affiliation): Reese L. Sorenson and William R. Van Dalsem,
Ames Research Center, Moffett Field, CA 94035-1000
Joseph L. Steger, University of California, Davis

Date of report: Oct. 22, 1991 Initiation year: FY91 Expected completion date: FY93

Funding total prior to FY91: ____ Funding authorized in FY91: $40,000

Estimated expended in FY91: $40,000 Funds requested for FY92, if any: $40,000

In-house

Contracts (identify) $5,002 ICE Contract for computer hardware

Grants (identify) $34,998 University Consortium NCA2-655

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____ to Other (identify) ____

Purpose of investigation

To provide software tools allowing simplified mesh decomposition methods to be used in Chimera grid generation, allowing fast mesh generation and re-generation.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Develop software as described in University Consortium Agreement

For studies terminated before FY91 (any accomplishments/applications not previously reported)

No narrative report

Prepared by: Reese L. Sorenson Org. Code: RFA MS: T045-2 Phone: (415) 604-4471

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: The Effects of Altered Gravity on Human Smooth-Pursuit Eye Movements

Investigator(s) (show affiliation): Leland S. Stone and Malcolm Cohen, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Sept. 30, 1991 Initiation year: FY91 Expected completion date: FY92

Funding total prior to FY91: _____ Funding authorized in FY91: $40,000

Estimated expended in FY91: Funds requested for FY92, if any: $40,000

In-house: $40,000 (also $60,000 RTOP funds used)
Contracts (identify):
Grants (identify):

Status of study: ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92: ☐ with funds remaining? ☒ with FY92 funds?

If transitioned to other funding, to RTOP (number?): _____

to Program (name?): _____ to Other (identify): _____

Purpose of investigation

To measure smooth-pursuit eye movements during centrifugation in order to examine directly the effect of gravity on the sensory processing (both visual and vestibular) underlying the control of a voluntary coordinated movement with minimal Coriolis or biomechanical artifacts.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Have ordered eye-tracker and appropriate data acquisition system. Will begin study when equipment arrives in early 1992.

Planned future work

To measure smooth-pursuit eye movements in both 1-g and hyper-g environment using the 20g centrifuge.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

No narrative report

Prepared by: Leland S. Stone Org. Code: SL MS: 262-2 Phone: (415) 604-3240

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation A Nonlinear Dynamical Approach to Numerical Method Development in CFD

Investigator(s) (show affiliation) H. C. Yee, Ames Research Center, Moffett Field, CA 94035-1000; P. K. Sweby, University of Reading, Reading, England; A. Lafon, ONERA-CERT, Toulouse, France; A. M. Stuart, University of Bath, Bath, England; and D. F. Griffiths, University of Dundee, Dundee, Scotland

Date of report Oct. 28, 1991 Initiation year FY90 Expected completion date FY91

Funding total prior to FY91 $35,000 Funding authorized in FY91 $35,000

Estimated expended in FY91: $35,000 Funds requested for FY92, if any _____

In-house Ames Associate (from ONERA/CERT, France, one year)
Contracts (identify) visiting scientists via Sterling Software
Grants (identify)

Status of study ☐ Completed in FY91 ☒ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation
Utilize non-linear dynamics theory to investigate problems of steady-state numerical solutions in CFD.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.
Eleven publications issued or in process, nine presentations and lectures. (See narrative in this report.)

Planned future work
Although analytical explanations of the permissibility of spurious numerical solutions have been uncovered, avoiding these phenomena in practical computations will be difficult. Improvement in this direction is a subject of ongoing research.

For studies terminated before FY91 (any accomplishments/applications not previously reported)
(See narrative in this report.)

Prepared by H. C. Yee Org. Code RF MS 202A Phone (415) 604-4769

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation: Climatology of the El Chichon Volcanic Cloud in the Stratosphere

Investigator(s) (show affiliation): Richard E. Young, Ames Research Center, Moffett Field, CA 94035-1000

Date of report: Oct. 1991 Initiation year: FY90 Expected completion date: FY91

Funding total prior to FY91: $35,000 Funding authorized in FY91: $35,000

Estimated expended in FY91: Funds requested for FY92, if any:

- In-house: $10,000
- Contracts (identify): $25,000 (Space Research Institute, for Programming Support)
- Grants (identify):

Status of study: ☒ Completed in FY91 ☐ Terminated in FY91 ☐ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?):

to Program (name?): to Other (identify):

Purpose of investigation

To numerically simulate the behavior of the El Chichon volcanic aerosol cloud in the Earth's stratosphere and compare the results to observed cloud climatology.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Paper to be submitted to AGU Chapman Conference on Climate, Volcanoes, and Global Change, March 23-27, 1992.

Planned future work

Have submitted proposal to NASA's Volcano Climate Interaction Program to fund further modeling of El Chichon and Mt. Pinatubo volcanoes.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by: Richard E. Young Org. Code: SST MS: 245-3 Phone: (415) 604-5521

NASA
Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Title of Investigation Development of Excrescence Tolerance Criteria for Laminar Flow Wings at Low Subsonic Speeds

Investigator(s) (show affiliation) Fanny A. Zuniga, Ames Dryden Flight Research Facility, Edwards, CA 93523-0273

Date of report Oct. 1991 Initiation year FY91 Expected completion date FY92

Funding total prior to FY91 _____ Funding authorized in FY91 $35,000

Estimated expended in FY91: $35,000
In-house
Contracts (identify)
Grants (identify)

Funds requested for FY92, if any $40,000

Status of study ☐ Completed in FY91 ☐ Terminated in FY91 ☒ Continued in FY92

If continued in FY92 ☐ with funds remaining? ☐ with FY92 funds?

If transitioned to other funding, to RTOP (number?) _____

to Program (name?) _____ to Other (identify) _____

Purpose of investigation

To evaluate and extend current criteria used to define excrescence tolerances for a laminar flow wing at low subsonic speeds.

FY91 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Flight testing is continuing. Future plans consist of completing the initial test matrix in order to meet the objectives of the investigation. Also, use of multi-element sensors is planned in order to improve quality of data.

For studies terminated before FY91 (any accomplishments/applications not previously reported)

Prepared by Fanny A. Zuniga Org. Code XRA MS D-2045 Phone (805) 258-2021

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Moffett Field, CA 94035-1000

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13. ABSTRACT *(Maximum 200 words)*

This technical memorandum contains brief technical papers describing research and technology development programs sponsored by the Ames Research Center Director's Discretionary Fund during fiscal year 1991 (Oct. 1990 through Sep. 1991). An appendix provides administrative information for each of the sponsored research programs.

14. SUBJECT TERMS

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